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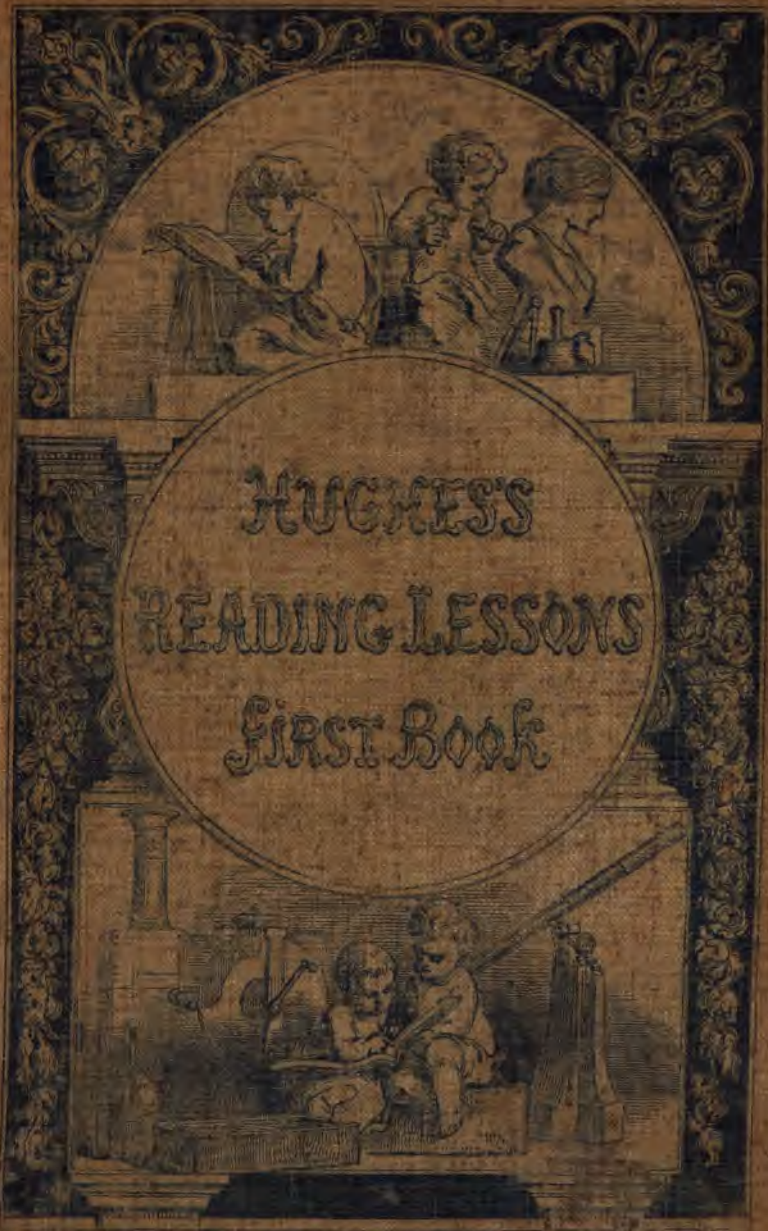

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READING LESSONS.

First Book.

EDITED BY

EDWARD HUGHES,

HEAD MASTER OF THE ROYAL NAVAL LOWER SCHOOL,
GREENWICH HOSPITAL.

WITH NUMEROUS ILLUSTRATIONS.

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1855.

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500. a. 98
3987.f.101.

LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

PREFACE.

THE series of Reading Lessons, of which this is a part, has been undertaken with the double object of supplying to parents and teachers an aid in developing the intelligence and enlarging the knowledge of young minds, and at the same time affording a course of essentially English Reading Books. The substantial information contained in them has been specially prepared by writers eminent in their particular departments of Literature, Science, and Art; and as the various articles have been written by different authors, they afford sufficient diversity in style and diction to form a sound exercise in the vocabulary and forms of our language.

The Editor refers with pleasure and satisfaction to the list of distinguished men whose assistance and encouragement he has received in the preparation of this series. Their support gives him a confidence which he could not feel in himself; and it speaks well for the intellectual progress of the future, that men of such ability think it not beneath them to popularise for the young those sciences of which they are themselves successful cultivators, and, in many instances, the acknowledged leaders.

The plan which has been adopted, after mature and careful consideration, is that of making each book of the series a complete platform of knowledge, upon which the mind may, as it were, rest, and take a general view before ascending to a higher stage.

Attempts are now being made to set aside scientific arrangement altogether in school-books, and regulate the lessons upon the natural suggestion of objects surrounding us, and things said to be "practically useful." The objection to this is—that however valuable a knowledge of "common things" be, it must not be acquired at a loss of intellectual training. Facts and principles committed to memory without order or arrangement are soon forgotten, and at best can only give a show of smartness, but will never conduce to the higher object of education, that of informing the mind and disciplining its powers. "Common things" should no doubt be learned, and they will be carefully attended to in this series, but each in its place where the principle upon which it depends may be traced to its source.

"Without an intelligent teacher you cannot have intelligent pupils" may be considered an axiom in education; and so the Editor has not attempted to supersede the office of the teacher, but rather to put into the hands of pupils a text-book, not written down to infantile minds, but quite intelligible to youths of ordinary capacity who desire to comprehend facts and learn how they are related to each other.

The substance of the present volume has been for some months used as a text-book in the school under the Editor's care, and been found well adapted for its purpose. He now submits the work to the public in the fullest confidence that it will be found to convey most useful information to pupils, and in the hope that it will give general satisfaction to teachers.

E. H.

ROYAL NAVAL SCHOOLS,
GREENWICH HOSPITAL,
January 1, 1855.

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READING LESSONS.

FIRST BOOK.

Mental Culture.

BY EDWARD PURCELL.

LESSON I.

HOW TO GET KNOWLEDGE.

"Take fast hold of instruction; let her not go: keep her, for she is thy life."

1. Every portion of our nature requires its appropriate nourishment, deprived of which it soon becomes languid, and gradually loses all vigour and pines away. Our animal frame, we all know, must be supplied with daily food, and we take every care to satisfy its demands; but man, as a rational and spiritual being cannot "live by bread alone," his soul requires that sustenance which is given by "every word that proceedeth out of the mouth of God"—it languishes without the feeling and practice of religion; and his intellect must be nurtured by the loving spirit of wisdom, *to give it health* and strength by invigorating *draughts of knowledge.*

2. Knowledge is the food *of the mind*—a food that never cloys or surfeits, but rather is every day better relished and more easily digested. Not merely does it satisfy and sustain our intellectual nature, but it is self-supplying; for each accession that we make to our stock greatly increases the power and the opportunities for acquiring more, and the sources from which it is drawn are

too copious for us ever to fear an exhaustion of the supply. It is true that, by a benevolent necessity attached to our condition, knowledge, like every other good, cannot be acquired without labour, otherwise our faculties would grow torpid from want of exercise; but this labour heightens our enjoyment of it after a successful pursuit, as the manly and healthy toil of the labourer sweetens his hard-earned meal, and renders it more grateful and nutritious than the costly luxuries of pampered idleness.

3. The taste for knowledge, and the love of it, are amongst the purest, noblest, and most enduring sources of human happiness; and, fortunately for us, we live in an age and country in which many of the difficulties which beset the path of the learner have been removed. Education is becoming every day improved in its character and more accessible to all; the strong intellects among us take a pleasure in directing the steps of the feeble; and, under the blessing of a free constitution, a career of honourable distinction is open to all.

4. The way to get knowledge is to keep all our faculties in proper exercise upon the subjects suited to the special ability of each, and so to obtain a harmonious action of all our powers, each aiding the other when it is weak, or checking it and correcting its hasty conclusions when it is too self-reliant. The senses, the intellect, the moral perception and love of truth, must all work together, or the result will be unsatisfactory, and our mere information unworthy of the name of knowledge. Without the last, in particular—without an ingenuous seeking of truth for its own sake—all the facts we collect will be but dry faggots, unvivified by the sap which forms the flowers and fruits—the beauty and utility—of wisdom.

To become wise we must *think* and reflect; we must turn the full attention of the mind upon the subject before it, and backward upon itself. The materials for thought are drawn from what we *observe*, or *hear*, or *read;* and under each of these heads I shall make a few observations.

5. **Knowledge from Observation.**—By the impressions produced upon the senses, our attention is constantly drawn to the material things in the world without us. We can also, through *consciousness*, watch the operations and changes of our own minds—investigate our inner world, and so lay the foundation of mental science. But, whatever we observe, the facts thus acquired are only "broken knowledge," or rather they are the mere materials of it—the dead bricks out of which thought builds the edifice.

As soon as we have clearly ascertained what the phenomenon examined *is*, we should set the mind to work to find out all about it. We should investigate its *relations*. Amongst the numerous inquiries suggested by any object, the following may be enumerated as examples:—To what general class does it belong? How is it produced—naturally or artificially? Where does it come from, and its comparative abundance or scarcity? What are its chief properties and their uses, and could any other substance be advantageously substituted for it?

6. Generally, when engaged in active observation, we have some purpose to serve; for a mere vagrant curiosity, which leaves no permanent impression, is satisfied with a superficial glance. This purpose will, to a great extent, guide us in the kind of inquiries we ought to make. Thus, the naturalist will attend most to classification, mode of production, &c.; the geographer, to the place whence the production is obtained; the manufacturer, to its uses; the merchant, to its abundance or scarcity: so that the same object may be cross-examined in a variety of ways to obtain the special information each man requires; but, until every possible question has been asked and answered, our knowledge of the matter cannot be considered complete.

7. In addition to these sensible relations, there are others existing between objects, which the senses rather suggest to the mind than give any actual knowledge of

—such as those of position in *space;* succession in *time;* and *cause and effect.* Upon these conceptions of the intellect is constructed a class of sciences which, in the splendour of their results and the strictness of their demonstrations, far excel any merely sensible knowledge, and exhibit in the most striking point of view the innate power of thought with which we are endowed. The vast field for inquiry which geometry, in all its applications, opens to the mind, could never have been entered upon by the mere perceptions of the senses; nor, indeed, would any of the sciences be possible without the application of those mental principles of thought which are a part of our rational nature.

The mistake to which we are practically most liable in examining the relations of things, is that of taking a mere antecedent for the cause of a phenomenon; and this error we find constantly made by ignorant people, who are led into much absurdity and foolish superstition by supposing that, because one thing went before another, it has caused it.

8. ORAL INSTRUCTION.—In infancy and boyhood a great portion of the knowledge we acquire is drawn from verbal teaching. The mother's voice gives us our first lessons in truth and knowledge, and instruction coming from the lips of love finds an easy entrance to the infant mind. In a few years the teacher takes the place of the parent as instructor, and by his words our knowledge is enlarged and our pursuit of it directed. His experience shows us where difficulties are likely to be met with, his advice assists us in overcoming them, and his encouragement and approbation give confidence to the diffident and stimulate the slothful. To the young mind, indeed, oral instruction conveys knowledge in the most vivid and agreeable manner. The teacher prepares the information he wishes to communicate in a manner suited to the capacity of those whom he is addressing; he puts it in that form in which it can be most readily received, and introduces illustrations or examples of his

meaning as he sees they are required; he is also enabled by maps, drawings, and models, to make the eye assist the words, and so gets an entrance to the mind by two senses at once; above all, the sound of the voice and the appearance of a living instructor produce a more lively impression on the mind than the sight of a page of type. It was thus that, in the groves of Academus, Plato first roused his hearers to the pursuit of the good, the beautiful, the true; it was thus that our Lord himself and his apostles awakened the hearts of men to the reception of sacred truth.

9. To derive the full benefit from what we hear, we should be attentive and submissive to our teachers; not, however, blindly receiving what we are told, and storing up in the memory mere words, but endeavouring thoroughly to comprehend their instruction, and to make it our own by digesting it in the mind. Writing down from memory the heads of what we have heard, and trying to reproduce the substance of it in after thought, is the best mode of rendering a lecture really useful. If we do not understand what we hear, we should not look wise and try to appear as if we did, but note down our doubts and difficulties, and seek an opportunity of obtaining fuller information. Nor should we rest satisfied with what we hear in lectures, and let them encourage idleness into a neglect of private study; but rather, by suggesting difficulties and opening up new lines of investigation, stimulate us to farther research in books.

10. Not only in youth but at every period of our lives we can, by keeping our ears open and our attention awake, secure much valuable information. From the conversation of intelligent persons, even though their education and general knowledge be inferior to our own, much more if they be our superiors in both, we can learn a great deal by talking to them upon their own subjects. A skilful and thoughtful artizan can tell much about his art that it does not misbecome the most profound philo-

sopher to be acquainted with; for long experience and practice in the application of any particular class of objects often throw a new light upon scientific reasoning as to their character and properties. To derive advantage in this way, we should be more anxious to hear than to talk. We should free our minds from the stupid vanity which prompts a display of our knowledge, and listen patiently to pick up the grains of wisdom, even though they should be mixed with much dross, thrown out by others in the course of conversation. A pertinent question will no doubt often serve to bring out the information we want; and, while anxious to avoid display, we should be always ready to communicate our knowledge. This is a duty which we owe to our fellows. You should never, said the ancient Stoics, refuse a stranger a light from your hearth—it takes nothing from you, while it is a great benefit to him; and the same may with equal justice be said of the torch of knowledge. Imparting from it to others does not diminish our light, and may serve to guide them in the path of truth.

LESSON II.

KNOWLEDGE.

The lion o'er his wild domains
  Rules with the terror of his eye;
The eagle of the rock maintains
  By force his empire in the sky;
The shark, the tyrant of the flood,
  Reigns through the deep with quenchless rage:
Parent and young, unweaned from blood,
  Are still the same from age to age.

Of all that live, and move, and breathe,
  Man only rises o'er his birth;
He looks above, around, beneath,
  At once the heir of heaven and earth:

Force, cunning, speed, which Nature gave
  The various tribes throughout her plan,
Life to enjoy, from death to save,—
  These are the lowest powers of man.

From strength to strength he travels on:
  He leaves the lingering brute behind;
And when a few short years are gone,
  He soars a disembodied mind:
Beyond the grave his course sublime
  Destined through nobler paths to run,
In his career the end of Time
  Is but Eternity begun.

What guides him in his high pursuit,
  Opens, illumines, cheers his way,
Discerns the immortal from the brute,
  God's image from the mould of clay?
'Tis Knowledge:—Knowledge to the soul
  Is power, and liberty, and peace;
And while celestial ages roll,
  The joys of Knowledge shall increase.

Hail to the glorious plans that spread
  The light with universal beams,
And through the human desert led
  Truth's living, pure, perpetual streams!
Behold a new creation rise,
  New spirit breathed into the clod,
Where'er the voice of Wisdom cries,
  "Man, know thyself, and fear thy God."

JAMES MONTGOMERY.

LESSON III.

WRITTEN KNOWLEDGE.

"What strange art, what magic can dispose
The troubled mind to change its native woes?
Or lead us willing from ourselves, to see
Others more wretched, more undone than we?
This *books* can do;—nor this alone; they give
New views to life, and teach us how to live;
They soothe the grieved, the stubborn they chastise,
Fools they admonish, and confirm the wise:
Their aid they yield to all; they never shun
The man of sorrow, nor the wretch undone:
Unlike the hard, the selfish, and the proud,
They fly not sullen from the suppliant crowd;
Nor tell to various people various things,
But show to subjects what they show to kings."

1. Reading is, in modern times, since the invention of the glorious art of printing, and the consequent multiplication of books, the great source whence we draw our knowledge.

What one man, though gifted with the noblest faculties, could accomplish in his lifetime by his unassisted observation and thought, would be but small had he to commence every subject for himself, for, as the poet says,

"Art is long, and time is fleeting,
And our hearts, though stout and brave,
Still like muffled drums are beating
Funeral marches to the grave."

We can trace, in the instinctive acts of animals, no improvement or progression from age to age; but when a man dies his wisdom need not perish with him, he can bequeath it in books as a heritage for all time—a possession as lasting as the human race. His successor in the pursuit of knowledge thus starts from a more favourable position, and adds to the stock which he has inherited; so that our mental treasures increase and accumulate, and knowledge sweeps out in ever-widening circles. The great thinkers of our race still live and act through their works, "for books are not absolutely dead things, but do contain a progeny of life in them, to be as active as that soul was whose progeny they are; nay, they do preserve, as in a vial, the purest efficacy and extraction of that living intellect which bred them." "A good book is the precious life-blood of a master-spirit, embalmed and treasured up on purpose to a life beyond life."

2. Our forefathers have, in truth, worked so hard for our benefit through a long succession of years that they have left a large inheritance to us who are "the heirs of all the ages in the foremost files of time." The property thus stored up for our comfort and advantage does not consist of money, or houses, or lands, or any of those things which are ordinarily called valuable, but it is worth more than them all; for it generally enables its possessor to acquire them, and, if not, it makes him endure their absence with a contented mind. The wealth which has thus become the birthright of every man, rich or poor as he may be in worldly goods, is that for which the great Alfred sighed, and which Peter descended from a throne to acquire—it is that in the pursuit of which sages have spent laborious days and watchful nights, and which has added a double glory to the crown of kings and rulers who have been wise enough to prize it. Our great patrimony is knowledge, which strengthens and ennobles the mind, and aids us in rising to the full dignity of manhood.

3. So wide and extensive is the domain thus transmitted to us, that much of our youth and early manhood is devoted to learning how to enter on possession, and the whole of a lifetime would not suffice for us to traverse the entire extent of our property, and survey the wide and fertile fields and pleasant and varied districts won for us by the toils of great men who have gone before us. Those, however, who do not make any effort to ascertain what wealth they are entitled to, may surely be said to despise their birthright and wilfully to deprive themselves of the advantage acquired for them. How dull should we all consider that young man to be, who, pointing to a

cabinet, should say, "That was left me by my ancestors, and I am told it is full of precious gems and metals, but it has been ordered that no one shall open it for me, and the lock appears so stiff, I have never had the patience to examine it!" Should we not either pity his folly or despise his indolence? Yet this is what he is every day doing who is too idle or careless to make himself master of the treasures which books contain.

4. To make our reading profitable, we should be careful both in our selection of books and in the way in which we peruse them. There is no power that may not be enlisted in the service of evil or wasted in frivolity; and that art which is, when properly employed, so efficacious in spreading knowledge amongst mankind, has been too often used to disseminate folly, and even wickedness and vice. Many bad and injurious books have issued from the press, and are being daily published —books which, instead of ennobling, degrade our nature, and, even when free from actual vice, insult human reason by the absurdity and improbability of the nonsense woven together into the texture of a volume. The reading of such books can do no good; it must weaken, if it does not debase, the mind; and so many valuable works are accessible to all, that there is no excuse for the reading of even indifferent books. The purpose of every true author is to make his readers wiser or better, to delight their imagination by graceful fancies and truthful pictures, or to strengthen their intellectual and moral nature. It is the works of writers who propose to themselves these legitimate ends that alone are worthy of the attention of accountable beings. Nor is our selection difficult. Honest books, like honest men, are generally known by the character they bear; they become spoken of by the wise and quoted by the learned, and obtain a good repute even amongst those who never read them. The name of an author, too, who has established a reputation, is deservedly a recommendation of his future works, as the brand of a known manufacturer is received as a guarantee of the genuineness of the article sold. Indeed, if we really

seek good books, we can always find them, since there are teachers or friends ready to assist us with advice upon the subject in case of doubt. Recollect how careful you would be, on meeting with a plant or fruit whose properties you did not know, not to satisfy your appetite upon it, until you had inquired from some one better acquainted with its nature, whether it was edible and wholesome—use the same caution about your mental food.

5. When a book has been properly selected, the next question of importance is how to read it with advantage, so as to obtain from it the greatest amount of pleasure and profit. There are some that hurry through a volume as a railway traveller does through an interesting district of country, so rapidly, that at the end a confused notion of a great number and variety of objects is all that remains in the memory; others lazily dawdle over pages under a misty impression that they are reading, when they are not in fact receiving a thought into their minds, but are merely wasting time. I do not mean that every book we read demands an equally serious study. "Some books," says Lord Bacon, "are to be tasted, others to be swallowed, and some few to be chewed and digested; that is, some books are to be read only in parts, others to be read but not curiously, and some few to be read wholly and with diligence and attention." The character of the book, then, must determine our mode of reading it, and this is consequently the first thing we should endeavour to ascertain. What is the object of the writer? Does he wish to amuse or to instruct, to address our imagination or our reason? Is he about to record facts, or to make deductions and lay down principles? The answer to these questions will generally be furnished by the mere title and preface, and by it our mode of reading should be determined.

6. In reading imaginative and descriptive works, we should endeavour to reproduce in our minds the pictures or scenes described in words. Thus, in reading travels in foreign countries, we should try to see all that

we are told; the physical appearance and vegetation, the people, their dresses, houses, and occupation, should all be sketched in "the mind's eye." Maps and drawings greatly assist in giving this vividness of impression to a written description. Similarly, with the creations of poetry, we should strive to see what the poet's fancy calls into existence, otherwise his lines will be at the best musically-assorted words, which please the ear but do not reach the mind. We should endeavour to participate in his feelings also, and when action is depicted, we should place the characters on a mimic stage, and view their relative positions and conduct.

7. Assertions of facts, and accounts of occurrences which we receive on the credibility of the author, are to be intrusted to the memory, not loosely, but each packed into a strong box with others of its own sort. In an argumentative work the great object should be to get a clear notion of whatever principles and conclusions it is intended to establish, and the several arguments brought forward in support of them. We should then estimate the validity and force of the reasoning, and form a judgment whether we can assent to the conclusions or not. Of course, in learning what has been already so firmly established as to be beyond doubt, for instance, in mathematical works, we have only to satisfy our minds that we trace clearly the process of deduction. But as in subjects less capable of certain proof, men sometimes wilfully, but still oftener unconsciously, put forward defective arguments, we must try to detect any sophistry that may lurk under apparent reasoning, and see that there is no broken link in the chain which connects the premises with the conclusion. The skill in rigid demonstration, and the habit of close attention acquired by even a moderate acquaintance with the pure sciences, give to the mind a great facility in separating the essential parts of an argument from the cloud of words in which feeling loves to clothe it, as well as acuteness in tracing the connection of the several parts of a line of reasoning. This is the great use of scientific studies in the forma-

tion of our minds: we may never in after life require their application, but our reasoning must always be strengthened by their influence.

8. Occasional self-examination in the course of reading affords most valuable resting-places for the attention, which is apt to get fatigued from too long a strain, and engraves the impression more deeply on the memory. At the end of each chapter, we should ask ourselves what it contains, and restate mentally its substance in a condensed form. If the mind has been wandering this will be impossible, and so we can detect our inattention before proceeding farther. It will also insure our comprehension of the subject, for we cannot clearly state even to ourselves what we do not understand, and it will commit it to the memory in a form most convenient for future use. When the style or subject is of peculiar difficulty, this process may be repeated with advantage at much shorter intervals, at the end of every page, or even paragraph; but with a large number of modern writers it is remarkable into what a small space several pages can be packed without injury.

9. This reproduction of the sense and substance of what we read in our own words can be still more effectively done in writing. A man of great learning is reported to have said, "When I want thoroughly to understand any subject, I write a book upon it." Not merely is the effort to put our knowledge into a written form the best test of its extent and accuracy, but also in the process of composition we must arrange and methodize our thoughts before we can express them in a proper form. Reading supplies *fulness* of information; conversation, *readiness* in its use; and writing, *exactness* in thought and expression.

10. Having offered these suggestions on the best mode of rendering our reading profitable, I shall conclude this subject with the eloquent words of one whose experience makes him well competent to judge of its pleasures, while his reputation throughout the civilized world shows the honours it can confer:—

"If," says Sir John Herschel, "I were to pray for a taste which should stand me in stead under every variety of circumstances, and be a source of happiness and cheerfulness to me through life, and a shield against its ills, however things might go amiss, and the world frown upon me, it would be a taste for reading—I speak of it, of course, not as superseding or derogating from the higher office, and surer and stronger panoply of religious principle—but as a taste, an instrument, and a mode of pleasurable gratification. Give a man this taste, and the means of gratifying it, and you can hardly fail of making a happy man, unless, indeed, you put into his hands a most perverse selection of books. You place him in contact with the best society in every period of history—with the wisest, the wittiest—with the tenderest, the bravest, and the purest characters who have adorned humanity. You make him a denizen of all nations—a contemporary of all ages. The world has been created for him. It is hardly possible but the character should take a higher and better tone from the constant habit of associating in thought with a class of thinkers, to say the least of it, above the average of humanity. It is morally impossible but that the manners should take a tinge of good breeding and civilization from having constantly before one's eyes the way in which the best-bred and the best-informed men have talked and conducted themselves in their intercourse with each other. There is a gentle but perfectly irresistible coercion in a habit of reading well directed, over the whole tenor of a man's character and conduct, which is not the less effectual because it works insensibly, and because it is really the last thing he dreams of. It civilizes the conduct of men, and suffers them not to remain barbarous."—EDWARD PURCELL.

KNOWLEDGE AND WISDOM.

Knowledge and Wisdom, far from being one,
Have oft-times no connection. Knowledge dwells
In heads replete with thoughts of other men;
Wisdom, in minds attentive to their own.
Knowledge—a rude, unprofitable mass,
The mere materials with which Wisdom builds,
Till smoothed, and squared, and fitted to its place—
Does but encumber whom it seems to enrich!
Knowledge is proud that he has learned so much,
Wisdom is humble that he knows no more.—Cowper.

Physical Geography.

LESSON I.

FORM OF THE EARTH.

BY EDWARD HUGHES.

"He stretcheth out the north over the empty place, and hangeth the earth upon nothing."

1. Whenever we look forth during daylight upon the earth's surface, the land appears to us broken into hills, dales, mountains, valleys, or plains, intersected, perhaps, by streams or broken by lakes. This varied surface may be portioned out into farms, pasture or corn-fields, and woodlands, and dotted over with villages, towns, and seats of the gentry; or our range of vision may take in portions of the mighty sea. Under these circumstances, our view is bounded for the most part by the natural inequalities of the district, or the structures raised by man upon the soil. If, however, we take our stand upon a level plain, or on the deck of a ship at sea, and so avoid these obstructions, the sky itself seems to form the boundary to our vision. Looking upwards we behold a vast canopy of blue sky, or of grey or whitish cloud, extending over the spot on which we stand. The glorious sun illumes this azure vault by day, and the gentle moon and twinkling stars adorn its surface by night.

2. If we follow the dome of the sky in a downward direction, and that of the surface of a level country, or

of the sea, in an outward one, we observe that the earth and sky seem to meet in a circle, which completely surrounds us, and in whatever direction we look bounds our view.

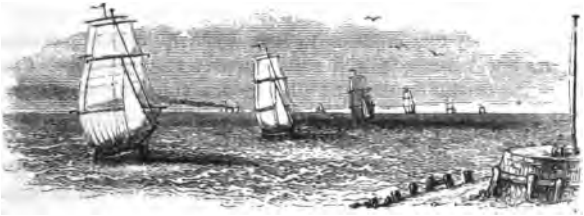
This circle upon which the canopy of the sky seems to rest, and which extends in every direction at an equal distance from the place upon which we are standing, is called the *horizon*, because it limits or bounds the extent of the visible earth and sky. Now, go where we will upon the surface of a plain or the sea, still we observe the same interval extending outwards from where we are placed, and the horizon not vanishing as we advance towards it, but presenting from every point of view a clear circular outline, which is well defined across the face of the sun and moon at the times of rising and setting.

3. We thus see that to a spectator on the surface of the earth, the *appearance* which it presents is either that of a broken irregular surface, more or less shut in by elevations, or of a circular plain, in the centre of which he stands; and in either case he feels that the portion within his view is very small compared with the whole extent of its surface. If, therefore, he wishes to ascertain the *general figure* of the large mass on which he stands, he must either remove to such a distance from it as to take in the whole at one view, which is beyond human power to accomplish, or he must extend his own observations, and compare them with those of others, so as to arrive at a general conclusion respecting the whole surface.

4. Now, although we cannot reach a sufficient distance from the earth to get a complete view of its shape, one fact appears clear, which is, that the inequalities would gradually disappear as we increased our distance, just as the roughness and irregularity of surface which have troubled a traveller in the ascent of a mountain, melt away into a general form and hue as he turns back to gaze upon it from a distance. Those who have ascended in balloons inform us, that when at a considerable elevation the earth looks like a map, flat, and varied

only in colour and shade. We may from this conclude, that the elevations and depressions of the earth which, from their nearness to us appear considerable, need not be taken into account in our inquiries as to its general figure; they merely show that the surface, whatever be its form, is *not smooth.*

5. As we thus see that the *roughness* of the earth need not interfere with our inquiries as to its form, let us for simplicity begin our observations with the smoothest surface, we can find, that of the sea.



Now, if on a clear day we look out from the beach upon the sea, its surface seems elevated or curved between our eye and ships in the distance. If the ships are approaching the shore, they appear to be advancing up this curve. At first we can only get sight of the topsails, but as they approach us the lower sails appear, and lastly the hull itself rises into view.

6. Again, when ships put out to sea in any direction, they appear to sail over the bulging surface of the sea; the hull first vanishes, then the sails, and at length the topmast alone is visible by a telescope, appearing like a pole planted in the water. This becomes gradually shorter, and at length disappears where the waters seem to curve down out of our sight. If we take a more elevated position, the same phenomena will be presented, only a greater distance will be necessary to produce the same apparent sinking of the vessel. The persons on shipboard, too, as they sail away from land, see the shore and high lands slowly sinking beneath the waters; and,

on the contrary, as they near the land, high objects seem gradually to rise out of the edge of the waters.

In like manner, when two ships are approaching each other out at sea, the mast-head of one ship first becomes visible to the crew of the other, and then the lower portions successively come into sight. And if the ships are sailing different courses, each seems to the other to sink behind the convexity of the waters.

7. When we go to the top of a high building, or ascend an eminence, we find that we obtain a more extensive view of the earth's surface, and this is why sailors go to the mast-head to look out for land, since from this elevated position they are enabled to look over a larger portion of the ocean surface, and consequently can see objects at a greater distance than when they are standing on deck.

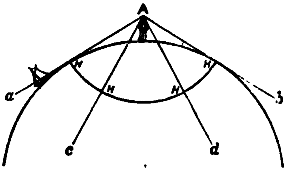
Persons who have ascended the Pyramids of Egypt have, as they gradually rose, obtained a more extensive view over the surrounding plains. Again, lofty mountains, such as Ætna, the Peak of Teneriffe, Mouna Roa, Cotopaxi, and Aconcagua, have been seen at sea on a clear day nearly one hundred miles distant; and it is well known that the sun gilds the summits of the Alps long after he has sunk beneath the western sky.

8. The exact amount of the depression arising from distance, and the increased surface visible at different elevations, have been ascertained by observation. Thus if the eye be depressed to the ground, the mast of a ship fifty feet in height will be visible at a distance of nine miles, while the deck, supposing it to be six feet above the water, is not visible until the vessel approaches within a distance of four miles. So invariable is this increase of depression with the distance, that by it we can estimate the distance of an object seen across a smooth surface, by knowing the height of the concealed portion, and allowing about a mile for every two feet; by similar calculations the whole size of the earth has been determined with considerable accuracy.

9. When the eye of a spectator is placed six feet above the earth's surface, there is a visible circle of the sea or

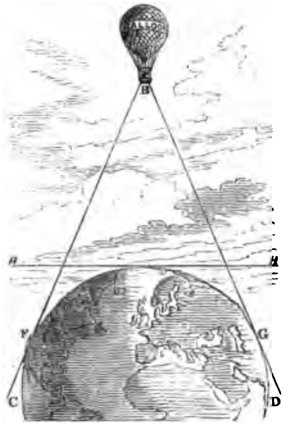
an even plain extending three miles and a quarter distant from the spot upon which he is standing. If the eye be elevated fifty feet, a distance of nine miles can be seen in every direction; and at the height of five thousand feet, ninety-three miles can be seen all around, embracing an area of twenty-seven thousand square miles. All these facts show us that the earth has a *convex surface*, that is, that it is curved, or bulges everywhere.

10. Let the earth's surface be represented by the annexed curve, and suppose a spectator placed at A, with his eye a few feet above the earth's surface; when he looks towards *a*, he can see the terrestrial surface as far as H, but no further, all beyond is bent round by the curvature out of his sight. When he looks towards *c*, *d* and *b*, he can see only as far as the letters H H H H. Let the line A H represent the visual ray along which the spectator sees the *visible horizon;* this line is called a *tangent*, and as it sweeps round towards *b*, and then towards *a*, it comes successively into the positions marked A H, and the points of contact mark out on the earth's surface the *circle* around which the letter H is placed. The area of the surface included within this circle is the portion of the earth's surface visible to the spectator at A.



11. Now it is evident that the higher we ascend into the atmosphere, the greater is the area of the segment or slice of the earth's surface that becomes visible. But from whatever height aëronauts who ascend in balloons look downwards, the earth always presents to them a *circular* boundary. On the 15th September 1804, MM. Biot and Gay Lussac ascended to the enormous height of 25,000 feet, or rather less than five miles, from which elevation they saw about one sixteen-hundredth part of the whole area of the earth's surface.

Now the same apparent shape has been observed on every portion of the earth's surface visited by man: a body therefore which, however seen, always appears *circular*, must have a constant circular convexity, and therefore can be no other than a *sphere* or globe.



12. Suppose an observer to occupy the car of a balloon, the visual rays B C and B D, as seen in the annexed cut, touch the earth at the points F and G. Let us imagine these lines to be the legs of a ruler jointed at B, and kept extended by the globe between them. It is clear that as the joint B is moved towards the surface, the legs will open and the points of contact become closer, and consequently the area of the circle less. When the ruler attains perfect straightness, its whole length, H H, becomes a *tangent* to the sphere. If the observer's eye be placed on the surface of the earth, then his horizon will be in the same plane with this line, and form a *tangent plane* with the earth's surface.

13. We have abundant practical proofs of the rotundity of the earth, in the direction of east and west, in the history of navigation, since numerous European and American vessels have sailed from certain ports, and by pursuing the same general course either easterly or westerly, have at length returned to the same place from which they set out. Such voyages are impossible in the direction from north to south, from the immense barriers of ice, which surround the poles; but we shall presently notice a class of facts, which tend to prove the earth's sphericity in that direction. Magalhaens,

Drake, and Anson, having been amongst the first who circumnavigated the globe, have acquired imperishable renown.

LESSON II.

THE FIRST VOYAGE ROUND THE WORLD.

"Many shall run to and fro, and knowledge shall be increased."

1. In the latter half of the fifteenth and early part of the sixteenth centuries, the Spaniards and Portuguese were the only European nations that were much engaged in prosecuting voyages of discovery in the southern regions of the earth—the Portuguese towards the *east* and the Spaniards towards the *west.* The spirit of maritime adventure had been cherished and wrought up to the highest pitch by the acquisitions of the Portuguese in the golden realms of India, lying beyond that promontory which the king of Portugal had sagaciously named the Cape of Good Hope.

2. At a later period, the courage and perseverance of Columbus enabled him to extend his voyages beyond the Western Isles, and to explore the mysteries of the Atlantic Ocean. On the 12th October, 1492, he discovered the Western world, and "secured to himself a glory which must be as durable as the world itself."

"Thy soul was nerved with more than mortal force,
  Bold mariner upon a chartless sea,
  With none to second—none to solace thee.
Alone who daredst keep thy resolute course,
  Through the broad waste of waters drear and dark,
'Mid wrathful skies, and howling winds, and worse,
The prayer, the taunt, the threat, the muttered curse
  Of all thy brethren in that fragile bark:
For on thy brow, throbbing with hopes immense,
  Had just Ambition set his royal mark,
Enriching thee with noble confidence,
  That having once thy venturous sails unfurled,
No danger should defeat thy recompense,
  The godlike gift to man of half the world."

3. In 1494, Spain and Portugal agreed that a line drawn from north to south, passing 18½ degrees to the west of the Azores, should be the boundary of their respective fields of maritime adventure. All new discoveries made 180 degrees to the west of this line were to belong to the Spaniards, and those made 180 degrees to the east of the same line were to belong to the Portuguese.

If we look at a globe or a map of the world we shall find in the Indian Seas, a few degrees on each side of the equator and between 120 and 130 degrees east longitude, a group of islands called the Moluccas or Spice Islands, which for centuries have exported cloves, nutmegs, mace, and sago to Europe, and birds' nests, trepang, and sharks' fins to China. These islands had been only lately discovered, and great value was set on them by both nations. According to the agreement, they evidently from their position come within the domain assigned to the Portuguese; but in those days geographers had not yet learned how to measure degrees of longitude with accuracy, consequently the dimensions of the earth were imperfectly known, and the right to possession under the treaty became a matter of dispute. The Portuguese were accustomed for several years to sail to their possessions in the Indian Seas round the Cape of Good Hope, first doubled by Diaz in 1486, and it became important to the Spaniards to discover a westerly route.

4. Now, about the year 1507, Nunez de Balboa had discovered the great southern ocean, the existence of which had been so nearly made out by Columbus himself. The eastern coast of South America had also been explored as far as 40 degrees south along the Brazilian coast, and the rapid trending of the coast line to the south-west, compared with the tapering form of Africa, suggested a similar termination of the land southwards, although the western coast of America was as yet entirely unknown.

From these facts and surmises, the Spaniards were led to suppose that the islands could be more easily reached by sailing west. and therefore lay within the limits assigned by treaty to Spain. Amongst those who held this opinion was Magalhaens, who must ever be regarded as one of the most enterprising of navigators, and in boldness, skill, and sagacity, a worthy rival of the great discoverer of the New World.

5. Fernando Magalhaens, commonly but incorrectly called *Magellan*, was born about the year 1470, in the province of Almetejo in Portugal. At an early age he entered the Portuguese navy, and served with distinction in the east; but on his return to Europe he was so dissatisfied by his services not being properly rewarded that he quitted Portugal and went to Valladolid, where he sought employment in the service of Spain. Desirous of distinguishing himself by some great enterprise, he formed the design of carrying out the bold conception of Columbus, that of passing round the south of the American continent into the great ocean, and sailing by a westerly course to Asia. He laid his plans for such a voyage before Charles the Fifth. They were approved by this monarch, who intrusted him with the command of a small fleet to explore the western ocean. The ships provided for the expedition were the Trinidad, the San Antonio, the Vittoria, the Conception, and the Santiago, whose united crews amounted to 236 men.

6. On the morning of the 20th September, 1519, this little fleet weighed anchor, and sailed from San Lucar de Barameda in the south of Spain. Magalhaens, with great judgment directed his course to the southern shores of Brazil, entered the La Plata river, and thence sailed southward. In the following April he reached a safe harbour in latitude 50°, to which he gave the name of St. Julian. It was now the beginning of winter, which in those high latitudes lasts with great severity till October, and he therefore determined to remain inactive during this period. The rigours of the climate, combined with a limited supply of provisions, caused the crews of the different ships to become discontented and

unruly. At length, it having become necessary to distribute the food sparingly, the men broke out into open mutiny, and demanded to be conducted back to Spain. A conspiracy, headed by the officers of the other ships, was formed against Magalhaens, in putting down which he displayed great firmness and resolution. Two of the captains he made prisoners openly and put to death. The ringleader, Captain Luis de Mendoza of the Vittoria, he caused to be stabbed on board that vessel, and another was put on shore on the inhospitable coast.

7. In the month of October, the commencement of the southern summer, he set sail from port St. Julian. Unfortunately, however, on quitting that harbour the Santiago was wrecked. Magalhaens pursued his course south, and in a few days entered the strait which still bears his name, "The strait of Magalhaens," situated at the southern extremity of the continent of South America. Here the San Antonio parted company from the other ships and returned home. Magalhaens felt confident on entering the opening that it was not a river but a channel or communication between two great oceans, since there was a strong current running continually westward, and upon sounding he found no bottom. He resolved therefore to proceed, and to his great joy on the 28th November he cleared the western extremity of the strait. Flushed with the feelings of triumphant success, he now steered boldly out into the unexplored expanse of the vast Pacific. On the 6th March he arrived at a group of islands, which he called Los Ladrones, from the inclination to theft which the inhabitants displayed. Here he refreshed his crew and continued his course westward; in three months and twenty days after he left the strait he reached the Philippine Isles. Having enjoyed constant fair weather and favourable winds, he gave to the ocean which he had crossed the name which it still bears, "the Pacific Ocean."

8. The length of the voyage had now reduced the

crew to the greatest distress for want of food. So great were their hardships that it was believed after their return that an expedition round the world would never be undertaken again, and indeed more than fifty years elapsed between the voyage of Magalhaens and that of Drake in 1577. It so happened that Magalhaens never sighted any of the numerous and well-peopled islands which have since been discovered in the equatorial and southern regions of the Pacific.

9. When he went on shore at the Philippines he was kindly received by the king of Zebu. It appears that this king was at war with one of the neighbouring chiefs, and was easily induced by a promise of assistance against his enemies to embrace Christianity, and acknowledge the sovereignty of the king of Spain. Magalhaens was soon called upon to fulfil his rash promise, and undertake an expedition against the king of the island of Mattan. The Spaniards had no sooner entered the hostile territory than they found themselves surrounded by a multitude, who attacked them with stones and other missiles. Relying too much upon the effect which their fire-arms were accustomed to produce on the American Indians, they advanced; but the islanders stood their ground and bravely resisted, until the Spaniards, finding their ammunition spent, began to retreat: as they gave way, the natives redoubled their attacks. Magalhaens was felled by the blow of a large stone on the head, a second broke his thigh, and a shower of lances deprived him of life. The king of Zebu, for whom Magalhaens had so wantonly hazarded his life, soon forgot his vows, and treacherously put to death all the Spaniards who returned to his island.

10. Those who remained on board the ships, when they learned the melancholy news of their companions and their chief, finding their numbers too few to manage three ships, burnt the Conception, and with the other two, the Trinidad and Vittoria, pursued their voyage in search of the Moluccas. These they reached safely, and were received kindly by the king of Tidor. The

Trinidad remained here some time for repairs, and afterwards attempted to reach America by crossing the Pacific, but was driven back and her crew made prisoners by the Portuguese. Meanwhile the Vittoria, under the command of Juan Sebastian del Cano, who had come out in the Conception as lieutenant, returned home by the Cape of Good Hope, and arrived at San Lucar on the 6th September, 1522, thus completing the first circumnavigation of the globe, and proving its rotundity in the direction of west to east. The good ship was drawn ashore, and long preserved as a monument of this most remarkable voyage.

11. The circumnavigation of the globe is now a matter of almost daily occurrence. The numerous vessels that trade between the British Islands and our Colonial possessions in Australia, sail round the Cape of Good Hope, and pursue an easterly course to Australia. The return voyages are made through the Pacific and round Cape Horn.

When Jùan Sebastian del Cano arrived at San Lucar he was surprised to find that he had lost a day by his reckoning. According to the account regularly kept on board the Vittoria, he appeared to arrive in port on the 5th September, but by the time on land his arrival was on the 6th September. Now this is the case with all vessels that sail round the world in a westerly direction, and those which sail round on an easterly course gain a day with respect to the places from which they set out. The explanation of this fact we shall reserve for a subsequent chapter.—Edward Hughes.

* * *

LAUNCHING INTO ETERNITY.

It was a brave attempt! adventurous he
Who in the first ship broke the unknown sea,
And, leaving his dear native shores behind,
Trusted his life to the licentious wind.

I see the surging brine; the tempest raves;
He on the pine-planks rides across the waves,
Exulting on the edge of thousand gaping graves;
He steers the wingéd boat, and shifts the sails,
Conquers the flood, and manages the gales.
  Such is the soul that leaves this mortal land,
Fearless, when the great Master gives command.
Death is the storm; she smiles to hear it roar,
And bids the tempest waft her from the shore;
Then with a skilful helm she sweeps the seas,
And manages the raging storm with ease;
(Her faith can govern death;) she spreads her wings
Wide to the wind, and as she sails she sings,
And loses by degrees the sight of mortal things.
As the shores lessen, so her joys arise,
The waves roll gentler, and the tempest dies;
Now vast eternity fills all her sight,
She floats on the broad deep with infinite delight,
The seas for ever calm, the skies for ever bright.

WATTS.

LESSON III.

SIZE AND FIGURE OF THE EARTH.

BY EDWARD HUGHES.

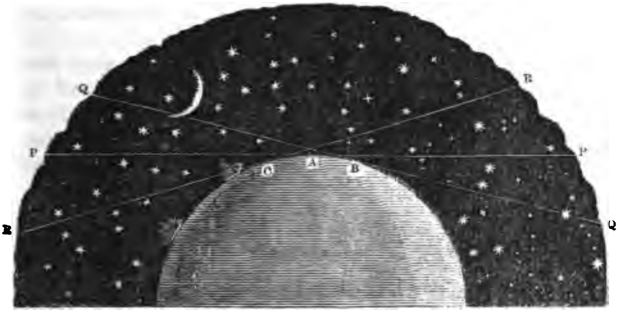
"For the whole world before thee is as a little grain of the balance, yea, as a drop of the morning dew that falleth down upon the earth."

1. IF on a cloudless night we look out towards the northern part of the heavens, we shall see certain stars that appear to us never to set; but to move in circles round a star which seems nearly stationary called the *Pole-star*. The stars near it, and describing circles round it, are called *circumpolar stars;* of which some of the most remarkable are those in the group or constellation of the Great Bear. Now, it is observed by travellers and voyagers, as they proceed for any considerable distance from north to south, that the pole-star, and those stars near it, appear gradually to descend towards the northern part of the horizon. As they journey onward towards the south, the stars in the constellation just mentioned appear to them, at first, to touch the horizon, then to

dip below it once in every twenty-four hours. At length the stars remain longer below the horizon, and finally disappear altogether.

2. But it is also observed, night after night, that as the northern stars are lost sight of, new stars rise above the southern horizon. The crews and passengers of vessels sailing from northern latitudes as far as the Cape of Good Hope, or farther south to Australia or Cape Horn, observe as they pursue their voyage that the northern stars disappear altogether, and that the southern and south circumpolar stars come into view. On the contrary, on a return voyage, the southern stars disappear, and the northern rise above the horizon. Now, if the earth were a cylinder, with its axis in the direction of north and south, as the traveller or voyager approached or receded from the equator, the north and south circumpolar stars would always appear above his horizon. But since it is found that as the observer approaches the northern or southern stars, they rise, and as he recedes from them they sink in the heavens, it is evident that either the star approaches the horizon or the horizon the star, or both approach one another at the same time. Now it has been shown that the horizon of the observer forms a *tangent plane* to the earth's surface; and it has also been shown that this plane alters continually its direction as the observer shifts his position. "Here then," says Professor Moseley, "is a complete geometrical proof of the curvature of the earth; for that surface which has, at different points, tangent planes in different positions, that is, which, when produced, do not coincide with one another, must be a curved surface. And on this supposition, the phenomenon is readily explained.

"Let A B C be different positions of the eye of our observer, and we may suppose his eye to be actually within the earth's surface, since his height is comparatively very small. Then will the planes C R, B Q, and A P, which must be imagined to be infinitely extended, be the horizons of the observer, or planes beneath which nothing will be seen by him in their several positions. It is apparent that, as he passes from A to C, his horizon, as it were, *rolls* with him; and by this motion, the distance between it and any star measured on that imaginary vault of the heavens, to which he refers the position of the star, is continually made to diminish; also, not being conscious of the motion of his horizon, he attributes the motion to the star, which he imagines to sink continually behind him as he moves onward."



3. Upon considering the figure of the sun, moon, and planets, we might be led to conclude that the earth did not form an exception to these celestial bodies, and therefore assume a similar shape; but the globular form of the earth is proved beyond doubt by lunar eclipses. These are caused by the moon entering the earth's shadow. The boundary of light and shade on the moon's face is always found to be circular; and since, at the period of successive eclipses, the earth is in different positions with respect to the moon, the body which always casts this shadow must be round, in every direction, or of a globular form.

> "The very law that moulds a tear,
> And bids it trickle from its source;
> That law preserves the earth a sphere,
> And guides the planets in their course."

Were the earth a disc, like the top of a round table, it would, when in certain positions relative to the sun and moon, project an oval shadow, or that of a right line or some other figure different from that which it has always been found to assume.

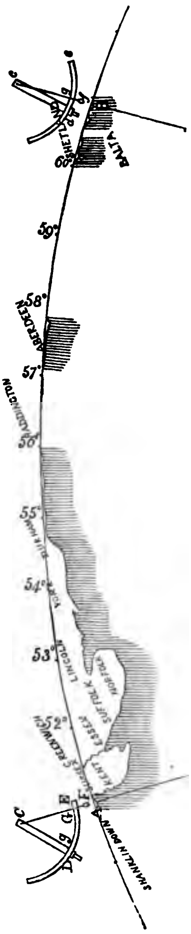
From what has been here stated, it follows that the surface of the earth is curved in every direction, and is, therefore, somewhat of a spherical form. Indeed, it is found to be orange-shaped ; and we shall now consider some of the means, by which its true form and size have been determined.

> "Thus far extend, thus far thy bounds,
> This be thy just circumference, O world !"

4. Since the earth is not a transparent mass, and since we cannot grasp it but only creep about upon its surface, just as a fly does upon that of an orange, and since we cannot recede from it far enough to view it as a whole, we can only apply our diminutive measures to small parts of it. By careful measurements of these parts, and by a certain line of reasoning, we can arrive at a tolerably correct conclusion as to the form and dimensions of the whole mass. "There is no manifestation," says the author last quoted "of wisdom in creation more remarkable, perhaps, than this—that a being so infinitely minute as man is, should be rendered able to ascertain the form and dimensions of the huge mass on which he dwells, and of other worlds than this, of equal or greater magnitude, situated at distances in the space around him so great, that large as they are, they are scarcely visible to him by reason of their remoteness." Since the earth has no landmarks on it to indicate degrees, or traces inscribed on its surface to guide us in a straight course, we must look outwards, and refer our situation on the surface of our globe to natural marks, *external* to it, and which are of equal permanence and stability with the earth itself. Such marks are afforded by the stars.

5. Let the annexed cut represent a section of the

British Islands from the Shetlands to the Isle of Wight. Suppose an observer to go to the little island of Balta in the Shetlands, and take with him a telescope, with its upper end resting upon pivots, and a graduated arc, D E. attached to its lower extremity. · From the upper end of the tube a plumb-line depends, which shows the direction of gravity, and is therefore perpendicular to the horizon. Now, let the telescope be directed to a star nearly overhead, the angle included between the telescope and the plumb-line shows how far the star is from the vertical. Then let the instrument be taken southwards to a place nearly on the same meridian, say to Shanklin Down on the Isle of Wight. If the earth be a curved surface, the direction in which the plumb-line hangs is not the same at different places, and it will be hereafter shown that the fixed stars are at such an immense distance from us that all lines drawn from the earth's surface to any one of them may be considered parallel to each other. Now, when the telescope is directed to the star, its place will be found to be unaltered, and the plumb-line here will be found to make a greater angle with the telescope than at Balta. Thus we obtain the difference of the direction of gravity at the two places. We have now the inclination of the line which is perpendicular to the surface at A, and the line which is perpendicular to the surface at B.



"If I continue these two lines downwards," says the Astronomer Royal, "until they meet at a great distance below, as at H, I shall get a centre from which I may make a sweep, to describe the curvature of this part. If the earth be spherical or round, it is plain that these lines come to the earth's centre, and the distance A H, which I have found, is the semi-diameter of the earth. If you take numbers, you will see how we assume this to be effected. Suppose the measure of A B is 830 miles. Suppose I find that the directions of the two vertical lines A H and B H in the two places A and B make an angle of twelve degrees. You will remember what a degree means. It is not a measure of length; it is a measure of inclination of these two lines. I have to pass over a distance of 830 miles, in order to get from one place to another, where the direction of the vertical changes twelve degrees. From that I infer that the curvature of the earth is such, that I have to pass over sixty-nine miles to find the distance of two places whose verticals are inclined one degree. Having got that, it is easy to find what is the semi-diameter of the circle which you must sweep, in order that that distance of sixty-nine miles may give one degree of inclination to the two lines, drawn from the centre to the ends of the sixty-nine mile arc. Making the calculation, you find the diameter is about 4,000 miles. And this is the way in which the measure of the earth was ascertained in the first instance. The first accurate measure was made in Holland, by a man named Snell, the next by a celebrated man, Picard, in France."

7. But this conclusion supposes the form of the earth to be a perfect sphere, and, in consequence, the length of its degrees in all parts precisely equal: when we come to compare the measures of meridional arcs made in various parts of the globe, we find, however, that its form is not exactly that of a sphere.

When the question of the figure of the earth came to be debated by astronomers, several European nations from time to time sent out expeditions to measure arcs of a meridian on different parts of the earth's surface. The results of these measurements show that the earth's curvature is greater near the equator than towards the poles; or, in other words, that the earth is flatter at the poles than at the equator: such a solid figure is called an oblate spheroid. It has also been shown that the polar diameter of the earth is about twenty-six miles shorter than the equatorial.

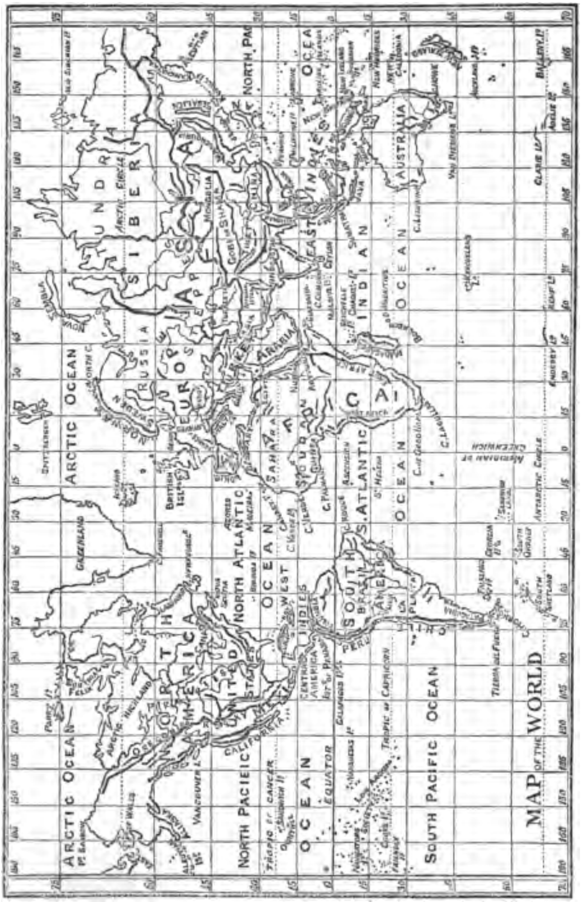
The following are the measurements of the earth as determined by Laplace:—

	English Miles.
Equatorial diameter - - - - - -	7,924
Polar diameter - - - - - - -	7,898
Mean diameter - - - - - - -	7,916
Mean circumference - - - - - -	24,860
Mean length of a degree - - - - -	69·08

Surface 196 millions of square miles.

8. The figure of the earth has also been deduced from pendulum experiments. Were the earth a perfect sphere, its attraction on bodies at its surface would be everywhere the same, and the velocities imparted to a weight when allowed to fall freely from the same height at different places would be equal. Now, the pendulum is in fact a falling body, and the greater the force of gravity, the greater the number of its oscillations in a given time. It has been found that a pendulum of a certain form and length, makes about 240 vibrations more in a day when near the pole than near the equator; hence we conclude that the force of gravity is less at the equator than towards the poles. Numerous and careful experiments of this kind have been made in different latitudes, and their general results agree well with those derived from computation on the supposition that the earth is a spheroid.

MAP OF THE WORLD ON MERCATOR'S PROJECTION.



LESSON IV.

LAND AND WATER.

" And God called the dry land Earth; and the gathering together of the waters called he Seas: and God saw that it was good."

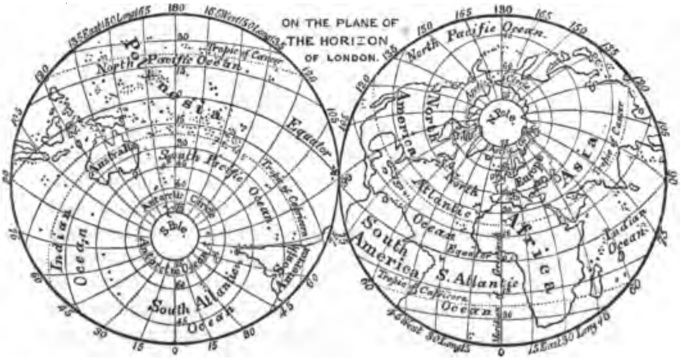
1. THE LAND.—In the last chapter we noticed some of the facts which tend to prove that the earth is a nearly round or spherical body. The most correct representations of its surface, therefore, can be made only on an artificial globe. But as it is difficult to construct globes sufficiently large to exhibit the earth's features distinctly, we are obliged to project maps which show the whole or portions of its surface. Various methods have been employed for this purpose, which it is not necessary here to enter upon. We shall therefore proceed to consider the distribution, area, and configuration of the Land and Water upon the surface of our planet.

2. The earth, strictly speaking, consists of three distinct parts; namely, a solid mass, the waters, and the atmosphere which surrounds both. The solid body of the earth is to a vast extent hollowed into deep basins, which are filled by the waters of the *sea* or *ocean*. Other portions of the solid mass protrude above the level of the ocean-waters and form *land*. The surface of the land is generally diversified by elevations and depressions, called mountains and valleys, which, though they appear to us of great dimensions, are too small, when compared with the magnitude of the earth, to affect its general form, and may, therefore, be compared to the little risings and hollows upon the peel of an orange.

3. When we look upon a terrestrial globe or a map of the world, such as that on the opposite page, we see that the greater part of the earth is covered by an immense expanse of water, extending from north to south, and surrounding numerous detached portions of land. For the sake of convenient reference this expanse of waters is divided into various parts, which are called oceans, seas, bays, gulfs, &c., according to their extent and situation. The largest of these divisions are the

Pacific and *Atlantic* oceans, which unite around the poles with two others called respectively the *Arctic* and *Antarctic* oceans. A fifth, called the *Indian Ocean*, lies to the west of the Pacific, of which it may be considered a portion. We also observe two large tracts of undivided land between these oceans, which are compact, and appear to hold together; these are called *Continents*. One is called the Eastern and the other the Western continent, because one lies east and the other west of the meridian upon which English maps of the globe are usually projected. Adjacent to the continents, and throughout the oceans, there are numerous smaller portions of land, surrounded by water, termed *Islands*.

4. It will be seen that the land, which occupies about three-tenth parts of the whole area of the globe, is very



unequally distributed over its surface. The greater part of it lies to the north of the equator, whilst to the south of that line we find only the narrow portions of the continents and some scattered islands. If we look at a map of the hemispheres, projected upon the plane of the horizon of London, we shall see that the hemisphere in which that city occupies the centre encloses nearly all the land upon the globe, while the other is almost covered with water; we may therefore call one the *land* or *continental* hemisphere, and the other the *water* or *oceanic* hemisphere.

5. The earth's surface has been estimated at about 196,500,000 of English square miles, and of this area the dry land occupies about 51,000,000 of square miles, and the ocean-waters about 145,500,000. It has also been calculated that there is about two and a half times as much land in the eastern as in the western hemisphere, and that there is about three times as much land to the north of the equator as to the south of it.

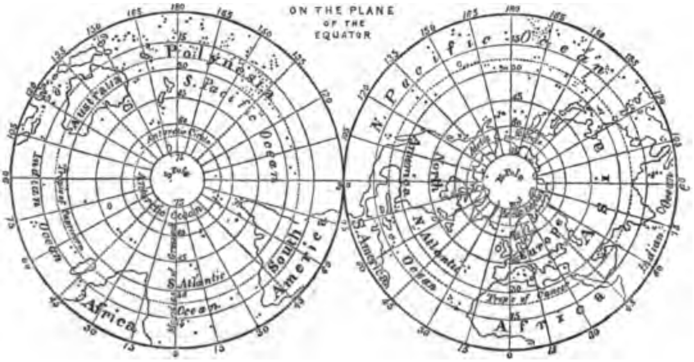
6. The land, as may be seen, is arranged into two large compact masses: that lying chiefly to the north of the equator, and forming the eastern continent, is broad and massive, and stretches from north-east to south-west over one-half of the circumference of the earth. The western continent, on the contrary, is long and narrow, and extends from north to south, almost from pole to pole. The result of this arrangement is that the eastern continent, extending as it does through similar climatic zones, presents less variety of phenomenon than the western, which traverses all the climatic zones of the globe.

7. A glance at the map will show to us that the two great continents are each made up of subdivisions, which, taken separately, are also called continents. Thus, the eastern comprises the continents of Europe, Asia, and Africa; and the western consists of North and South America. Australia, with some adjacent islands, form a fifth division of the globe, known under the name of Australasia; and a sixth division, called Polynesia, includes the islands scattered throughout the central and southern regions of the Pacific Ocean.

8. The continental masses appear to have been shattered by some great convulsion of Nature, and the islands, like fragments, severed and thrown off them. In some places the land projects into the sea; in others the sea penetrates the land, and splitting it up into various sections, renders its outline very irregular. The line of contact between the land and the margin waters

of the ocean, called a contour line, defines the boundaries and consequently determines the shape of the continents and islands upon the surface of the globe.

9. If we examine the map of the world attentively, we can scarcely fail to observe that the great masses of land in each hemisphere bear a general resemblance to each other in their outlines. First, each expands into broad extensive flats towards the north, where they are joined one to the other, while towards the south they gradually separate and narrow down to points. The northern sides are broad, low, and flat, but the southern extremities are pointed, lofty, and rocky. Thus Africa terminates in terraced plateaus at the Cape of Good Hope, and America in the rocky precipices of Cape Horn. The great mass of Southern Asia terminates in the high rocks of Cape Comorin, and Australia presents a similar abrupt extremity at Cape South-east in Van Diemen's Land. Not only do the principal masses of the continents contract and point towards the south, but also the chief limbs or peninsulas which they put forth, as Kamtschatka, Corea, and Malacca, in Asia; Greece, Italy, Spain, and Scandinavia, in Europe; Greenland, California, and Florida in America.



10. The Eastern and Western Continents present a

further similarity in their general configuration. Both are divided in the centre by a sea penetrating into the interior, and both extend their peninsulas, with few exceptions, southward. Each great mass situated to the north of the equator has a main body or trunk from which it sends off numerous limbs or peninsulas; whilst Africa and South America, which occupy nearly a similar position on the globe, are unpenetrated by the ocean, and in shape strikingly resemble each other.

11. Comparing the great masses of land among themselves, we find them arranged two by two into three groups:—1. Europe and Africa; 2. Asia and Australia; 3. North and South America; and these divisions will be found to present remarkable similarities in their horizontal contour and the relief of their surfaces. Each group consists of a northern and southern continent, united by an isthmus, or by a chain of islands. The northern continents are generally elongated from east to west, and consist of a body or centre, from which large peninsulas project towards the south, whilst the northern sides present an irregular outline of small low projections and islands. The two great southern continents are chiefly peninsulas, having a large projection on their western sides, and being joined at one of their northern angles to an adjacent continent. In each group, between the north and south continents, and lying to the east, there is an archipelago, the islands of which are almost similarly distributed.

12. This will be evident upon inspection of the groups. *First*, Asia and Australia, with the East Indian archipelago; *second*, Europe, with Africa and the Grecian archipelago; *third*, North and South America, with the archipelago of the West Indian islands. The best example of this grouping of the continents is to be found in the New World, where North and South America are nearly equal in size and similar in form, and are connected by a long and narrow isthmus; but the two groups in the Old World are less regular—the continents are of unequal size—the northern are joined

together, but the southern are separated from them. America and the group of Asia-Australia approach nearer to this normal type than Europe-Africa.

Upon examining the continents individually, we find a wide difference exists between them with regard to the extension of their line of contour. Some are deeply indented by the waters of the ocean, and being so, have an extensive line of coast; others are more compact and undivided, and have a simple and comparatively shorter coast line.

We shall now proceed to examine the general figure of the several subdivisions of the Eastern and Western Continents.

LESSON V.

THE LAND—*continued.*

1. **The Eastern Continent** is the largest mass of land upon the globe, extending for about 10,000 miles from east to west. and about 8,000 from north to south. It contains an area of about 33,000,000 of square miles, embracing the grand divisions of Europe, Asia, and Africa, each peculiar in its form and outline.

2. **Europe** may be considered a mere projection from the continental mass of Asia, to which it is connected by the broad base of the Uralian mountains and the Russian steppes. It is surrounded on three sides by arms of the ocean. Its greatest length, from Cape St. Vincent in the south-west, to the Gulf of Kara on the north-east, is about 3,500 miles. Its greatest breadth, from North Cape to Cape Matapan, is about 2,400 miles. The area of its surface, including the islands, amounts to about 3,500,000 square miles. It is, therefore, the smallest of the grand divisions of the globe. Europe is, of all the continents, the most varied in its horizontal contour, its principal mass being deeply cut into by inland seas.

3. If two straight lines be drawn from the Gulf of Kara,

one to the south-eastern corner of the Bay of Biscay, and the other to the northern extremity of the Caspian Sea, and a third line be drawn completing the triangle, within this figure will be included the main body of the continent. Outside of the figure we shall find, with the exception of Belgium and a part of France, only peninsulas and islands. On the south are the Grecian, Italian, and Spanish peninsulas, with the numerous islands in the Mediterranean Sea; on the north-west are the Scandinavian peninsula, with the small peninsulas of Brittany and Normandy, and the group of the British Islands.

4. In consequence of this structure, the coast-line is of great extent, and in proportion larger than that of any other of the grand divisions. Its line of shore extends about 17,000 miles; it therefore enjoys a mile of coast-line for every 156 square miles of surface. The result of this is, that almost all the countries of Europe are open to communication with the ocean. And thus it is that the inhabitants of this continent have advanced to a high state of civilization, and have been enabled to extend their commerce to every corner of the earth, to obtain the productions, knowledge, and arts of all other countries, and to scatter themselves over extensive regions of the globe.

5. Asia is the largest of the grand divisions of the earth: like Europe, it is surrounded on three sides by the ocean. Its greatest length from east to west is about 5,600 miles, and greatest breadth from north to south about 5,300 miles. It contains an area of about 17,500,000 square miles. The form of this continent has been compared to a broad curtain hanging from the coast of the Arctic Ocean. Its principal mass will be included within a rhombus formed by connecting certain points. Branching from this mighty trunk, are its members, which constitute a fifth of its mass. On the south are the large peninsulas of Arabia, Hindostan, and India beyond the Ganges; on the west there is the small one of Asia Minor; and on the east that of Kamtschatka, and the more enormous projections of

Manchooria and China. The eastern coast is lined by a range of islands, and from the south-east there stretches the extensive island group of the Indian archipelago. To this configuration Asia is indebted for a coast-line 30,800 miles.

6. The undivided and inaccessible mass of this continent is so great, that if we exclude the Arctic Ocean, which is scarcely navigable, there will be only 1 mile of sea-coast for every 459 square miles of surface. Hence in this grand division of the earth, the cradle of the human race, and which now contains more than half the population of the globe, civilization and improvement have scarcely penetrated beyond the peninsulas, except in the neighbourhood of the great inland seas, and along the courses of the great rivers. The peninsulas, from the extent of their coasts, and the consequent facilities which they offer for commerce, have been from the earliest ages the seats of population and civilization.

7. AFRICA is the third grand division of the Eastern Continent. Its greatest length from north to south is about 5,600 miles, and greatest breadth from east to west about 4,700 miles. Its area is about 11,300,000 square miles. It is entirely surrounded by the waters of the ocean, except at the Isthmus of Suez, by which it is connected to Asia. This continent presents a strong contrast to either Europe or Asia. It is almost closed to the ocean; forming a body without members. If we surround it with a line representing the vertical section of an egg, such a line will include the whole mass of land, except a few projecting points; and within it we shall find no considerable indentation of the sea, except the Gulf of Guinea. In consequence of its peculiar form, the extension of its coast-line is only 14,000 miles, or about 1 mile of sea-coast for every 623 square miles of surface, a proportion less than any other of the continents, and hence it is the most inaccessible, least civilized, and least known to civilized nations.

8. THE WESTERN CONTINENT, or America, which was first made known to Europeans by Columbus in 1492,

lies in the midst of the ocean that washes both shores of the Eastern Continent. It approaches within 40 miles of Asia in the west, and is connected with it by the chain of the Aleutian Islands. The whole length of the continent from north to south is about 8,700 miles. The greatest breadth is about 4,000 miles, and its least breadth, in the centre, across the Isthmus of Panama, about 30 miles. Its area contains about 14,000,000 square miles. The Gulf of Mexico divides it into two parts; North America in the Northern Hemisphere, and South America, nearly the whole of which is in the Southern Hemisphere. Between these two great divisions of the continent is situated the island group of the West Indian archipelago.

9. North America is the northern portion of the Western Continent. Its greatest length, from north to south, is about 5,600 miles, and its greatest breadth from east to west about 4,000 miles. It contains an area of about 8,600,000 square miles. Its shores are washed by the Atlantic on the east, and by the Pacific on the west. The main body of the continent may be included within a triangle, whose base extends along the northern shores, and whose vertical angle is in Mexico. The eastern side is penetrated by branches of the ocean, and consequently presents several peninsulas; and from the western side projects the long peninsula of California. These indented shores, which give to the continent a coast-line of 25,500 miles, or one mile to every 260 square miles of surface, are the means by which civilization and commerce have been promoted, and are now rapidly extending, into the interior.

10. South America is the smaller of the two divisions of the Western Continent. Its greatest length from north to south, is about 4,600 miles, and its greatest breadth from east to west about 3,000 miles; its area is about 6,420,000 square miles. Its form is triangular, and, like Africa, it is an immense mass of land without limbs or peninsulas. Its unbroken coast-line of 14,500 miles in extent, gives only a mile of sea-coast for

every 420 square miles of surface, and presents few bays, or even harbours. Hence civilization has spread only over the maritime regions of this continent, and even here it is in a low state, compared with the northern division of the New World.

ISLAND MASSES.

11. Australasia (South Asia) is a division of the globe which includes all those islands between the equator and latitude 47° S., consisting of the vast islands of Australia, Tasmania (Van Diemen's Land), New Guinea, and those islands lying between 130° and 170° E., viz.:—Papua, the Arru Isles, Timor, New Britain, New Ireland, New Caledonia, and the Admiralty, Solomon, New Hebrides, and Queen Charlotte's Isles.

Polynesia (Many Islands) includes the numerous islands scattered over the immense expanse of the Pacific Ocean, comprehending a belt chiefly within 30° on each side of the equator. The islands are distributed into several groups of an elongated form, and extending generally from north-west to south-east. The island groups consist chiefly of one or more larger islands and numerous smaller ones, and are all, more or less, of coral formation; some of these present the regular *atoll* form, with circular reefs and lagoons. The largest of the Polynesia groups is New Zealand; the remaining groups are comparatively small, and have numerous detached islands distributed around them.

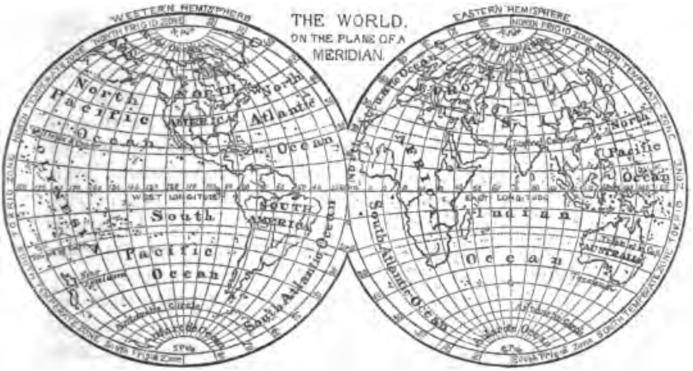
LESSON VI.

THE OCEAN.

> "The sea is his, and he made it: and his hands prepared the dry land."

1. The Ocean is the term used to indicate the extensive and continuous bodies of salt water which cover the greater part of the earth's surface. The waters of the

ocean occupy five great basins, which are distinguished by particular names as already mentioned.



The widest expanse of salt water is that which extends between America on the east and Asia and Australia on the west, and is called the ***Pacific Ocean.*** The next largest body of water is the ***Atlantic***, which lies between Europe and Africa on the east and America on the west. The ***Indian Ocean*** is situated between Africa on the west, and that immense chain of islands which stretches from Asia to Van Diemen's Land, on the east. The ***Arctic Ocean*** includes the waters within the Arctic circle; and the ***Antarctic Ocean*** embraces the waters within the Antarctic circle. There is a common feature in the general forms of the Pacific, Atlantic, and Indian Oceans. Towârds the north they are narrowed to points, and have broad expanses towards the south: the reverse of the continents. Each of these oceans, however, has a form peculiar to itself, and all differ in the configuration of their shores. Each sends off numerous branches into the land, which, according to their various forms, receive the name of ***gulfs***, ***land-locked*** or ***inland seas***. We shall now consider the form of the five great basins.

2. The Pacific Ocean is the largest expanse of water on the globe, covering more than half of its surface. The Arctic circle, at Behring's Strait, may be considered its northern boundary. From this line it extends southward to the Antarctic circle. Its eastern limit is formed by the western shores of America and the meridian of Cape Horn as far as the Antarctic circle, and its western limits are the eastern shores of Asia and the island of Sumatra, the northern shores of Java, Floris, and Timor, and the coast of Australia from Melville Island round the southern point of Van Diemen's Land, and along its meridian to the Antarctic circle. The area of this ocean has been roughly estimated at more than 100,000,000 of square miles.

3. From Behring's Strait, which is not more than 40 miles wide, the coasts of both continents, which enclose the Pacific, rapidly diverge from one another. At latitude 54° 30′ N. the peninsulas of Aliaska and Kamtschatka are upwards of 1,200 miles apart. Near the tropic of Cancer, the coast of California is distant from the east coast of China about 8,500 miles, and this is about the average width of this ocean between the tropics. Near the tropic of Capricorn, the northern coast of Chili is about 8,200 miles from Cape Sand in Australia. The equator divides this ocean into the North and South Pacific.

4. In form, the Pacific is somewhat oval shaped; from the south the continental shores gradually approach towards each other until at the Arctic circle they leave only a narrow passage by which the waters of the Pacific communicate with those of the Frozen Ocean. On the western side extensive peninsulas project from the mainland of Asia, and these with the adjacent rows of islands which stretch far into the sea, separate large portions of the continent from the ocean.

5. No part of the continent, therefore, is immediately washed by the main body of the Pacific Ocean, but its waters penetrate the land and form a series of sea-basins or land-locked seas, which succeed each other along the

eastern coast of Asia. Thus the Sea of Behring is divided from the Pacific by the peninsula of Aliaska and the Aleutian Islands. The Sea of Okhotsk is enclosed by the peninsula of Kamtschatka and the Kurile Islands. The Sea of Japan is separated from the ocean by an island chain of this name. The Yellow Sea is less distinctly separated from the Pacific by the islands of Loo Choo and Formosa. The Chinese Sea, locked by the Philippines, Borneo, and the Indo-China peninsula, may be considered the last link in this chain of sea-basins. Southward numerous groups of islands, chiefly of volcanic origin, with the large islands of New Guinea, Australia, and Van Diemen's Land, complete the western boundary of the Pacific.

6. On the east, the shores of the North American continent are more or less broken, but the only remarkable indentation is that of the Vermilion Sea, or Gulf of California. The South American coast presents an almost unbroken line throughout. The shores of the Pacific are in general high and lofty, and in some places of great elevation. The coast of Asia, with the exception of the shores of the Yellow Sea, the eastern coasts of China and Australia, with the intervening islands as far as they are known, are chiefly rocky, and of considerable elevation. The coasts of North America rise with a steep rocky ascent to a great height, and the coast-line preserves this character almost throughout its whole extent, except along the Isthmus of Panama, where the shores are low; but from this place they rise into lofty elevations, and southward of the equator, are generally several hundred feet in height, except at the mouths of the small rivers.

7. Turning from its shores to the ocean itself, we find a large belt of the Pacific between the tropics, extending from its western boundary to about 135° W. long., or more than half the whole width, scattered over with islands of different formations and various dimensions. Some are low and flat—others elevated and conical. The low islands are of small extent, and

formed by coral reefs, which encircle a small space resembling a lagoon, and hence these islands are sometimes called Lagoon Islands. The lofty islands are all volcanic, of moderate extent, and generally attain a great height in the centre. It will be observed that the principal island groups are situated in the western and south-western portions of this ocean; and that in the northern, eastern, and southern parts, only a few isolated islands occur, and but one considerable group, the Galapagos Islands, traversed by the equator. This ocean appears to be a deep sunken basin, which is nearly surrounded by the broken and elevated edges of the eastern shores of the old, and the western shores of the new continent. The whole length of its coast-line, including that of the Indian Ocean, has been estimated at about 47,000 miles.

8. The *Atlantic Ocean* is that part of the ocean waters which separates the New from the Old World; it washes the eastern shores of North and South America, and the western shores of Europe and Africa, extending from the Arctic circle on the north to the Antarctic circle on the south. Its western limit is formed by the American coast and the meridian of Cape Horn continued to the Antarctic circle; and its eastern limits are the shores of Europe and Africa and the meridian of Cape l'Agullas prolonged till it meets the Antarctic circle. The area of this ocean, including its numerous inland seas, is about 37,000,000 of square miles. Though the Atlantic extends 8,400 miles in length, its breadth is comparatively small. Between 69° and 71° N. lat., where the two continents which form its shores approach nearest to each other, the coasts of Greenland are only 800 miles from the opposite coasts of Norway.

9. The continental shores now gradually diverge from one another, until at the 30th parallel of N. lat., between the peninsula of Florida and the western coasts of Morocco in Africa, the opposite shores are separated by a distance of 3,600 geographical miles. From this

latitude the continents approach each other, until between Cape St. Roque, in Brazil, and the coast of Sierra Leone, in Africa, the distance is not more than 1,500 miles. This ocean is divided by the equator into the North and South Atlantic.

10. The Atlantic seems to be a simple depression. Its form has been compared to that of a trough or longitudinal valley, whose salient and re-entering angles correspond to one another. This is particularly the case with regard to the north-west part of Africa, and the north-east portion of South America. The North Atlantic Ocean is distinguished by a peculiarity of formation resulting from the indented and complicated line of its shore; but the South Atlantic offers little for remark, the form of its shores being simple and unbroken. An important feature of the North Atlantic is its connexion with land-locked or mediterranean seas. It sends off several arms, which penetrate far into the interior of both continents.

11. On the European side there is the Baltic, which is a completely land-locked sea; and the Mediterranean, properly so called, which penetrates with its branches for 3,000 miles into the very heart of the old Continent. On the American side there are the inland seas of Hudson's Bay and the Gulf of St. Lawrence, and the large sea-basins of the Gulf of Mexico and the Caribbean Sea. Comparatively speaking, there are few islands in the Atlantic, and these are chiefly of the continental class. The group of the British Islands, those of the Mediterranean and the Antilles, are the only archipelagos of great importance. The groups of the Azores, Madeira, the Canaries, Cape Verd, St. Helena, and a few others, are the *only representations* of what are termed pelagic islands.

12. This peculiarity of form brings the Atlantic and its appendages into immediate contact with a much greater extent of land than the other oceans. The continental shores of Europe, with those of Asia and Africa, give the Atlantic an eastern coast line of upwards of

28,000 geographical miles. The western or American shores comprehend about 20,000 geographical miles; consequently the whole shores of the Atlantic have a circuit of about 48,000 geographical miles. Hence it is evident that great are the advantages which such a peninsula offers for the progress of commerce and civilization.

13. The *Indian Ocean* extends from India and Persia on the north, to the Antarctic circle on the south. On the west it is limited by the shores of Arabia and Persia, as far south as Cape l'Agullas, and thence along the meridian of that cape to its intersection with the Antarctic circle. On the east it is limited by the west coast of the Birman empire, and a part of the Malay peninsula, the west coast of Sumatra, Java, Timor, and Australia, as far as the southernmost point of Van Diemen's Land, and thence continued along the meridian of that point to the Antarctic circle. The length and breadth of this ocean are each about 4,500 miles; and its area, including its branches, is upwards of 20,000,000 of square miles.

14. In form the Indian Ocean resembles the Pacific: on the north it is land-bound, and its coasts diverge from one another in a southerly direction. The Gulf or Bay of Bengal, and the Persian Sea, form the northern part of this ocean. From the last-mentioned sea two large inland seas, the Persian Gulf and the Red Sea, penetrate the Asiatic continent. On the east are the numerous islands of the oriental archipelago; but, omitting these, there are only the continental islands of Madagascar and Ceylon, and a few volcanic islands, as Mauritius and Bourbon, in this ocean.

15. The *Arctic Ocean* surrounds the North Pole, and is bounded by the northern shores of Asia, Europe, and America. Its principal branches are the White Sea, Sea of Kara, and the Gulf of Obi. It is nearly land-locked, except where it is connected with the Pacific by Behring's Strait, and with the Atlantic by the wide strait between Greenland and Norway. Its

area is estimated at about 3,000,000 of square miles. This ocean has been called the *Icy Sea*, from the circumstance of its being encumbered with heavy masses of ice all the year round. That part of the Arctic Ocean, where it borders on the Arctic circle, contains one of the largest archipelagos on the globe. On the east of Greenland there is the extensive group of islands known under the name of Spitzbergen, and the smaller island of Jan Mayen, and off the European shore there is the large island of Nova Zembla. On the west of Greenland, and divided from it by Davis' Strait and Baffin's Bay, there is a large group of islands, with whose outline and number we are imperfectly acquainted.

16. The *Antarctic Ocean* is that part of the ocean waters which is strictly included between the Antarctic circle and the South Pole; but as the ice extends further from the South Pole than it does from the North, the term is sometimes used to express generally the cold regions round the South Pole, without strict regard to the limits of the Antarctic circle. The area of the Antarctic Ocean is estimated at 2,000,000 square miles. Numerous exploring attempts have been made in these high southern latitudes, and a few pieces of land have been discovered, as Enderby's Land, Graham's Land, Biscoe's Range, and South Victoria.—EDWARD HUGHES.

SEA-SIDE THOUGHTS.

BEAUTIFUL, sublime, and glorious,
Mild, majestic, foaming, free;
Over time itself victorious;
Image of eternity.

Sun, and moon, and stars, shine o'er thee,
See thy surface ebb and flow,
Yet attempt not to explore thee,
In thy soundless depths below.

Whether morning's splendours steep thee
With the rainbow's glowing grace;
Tempests rouse, or navies sweep thee,
'Tis but for a moment's space.

Earth—her valleys, and her mountains,
Mortal man's behest obey:
Thy unfathomable fountains
Scoff his search and scorn his sway.

Such art thou, stupendous Ocean!
But if overwhelm'd by thee,
Can we think, without emotion,
What must thy Creator be?

BERNARD BARTON.

LESSON VII.

LIFE OF CAPTAIN JAMES COOK, R.N.

BY JOSEPH ALLEN, R.N.

"When Cook—lamented, and with tears as just
As ever mingled with heroic dust—
Steered Britain's oak into a world unknown,
And in his country's glory sought his own.
Wherever he found man to nature true,
The rights of man were sacred in his view;
He soothed with gifts, and greeted with a smile,
The simple native of the new-found isle;
He spurned the wretch that slighted or withstood
The tender argument of kindred blood,
Nor would endure, that any should control
His free-born brethren of the southern pole."

1. AMONGST the celebrated navigators whose discoveries have enlarged our knowledge of the form and surface of the earth, it would be difficult to name one—the great discoverer of the Western Continents excepted—who has contributed more to the advancement of geographical science than Captain James Cook. Twice he completed the circuit of the globe, through seas almost unknown; and his death in a distant island of the Pacific alone prevented the completion of a third. Considered also in another point of view, his life offers an interesting study; for it exhibits a striking example of the power of energy and perseverance to rise superior to any difficulties which may beset a youth at the commencement of his career in life. It is in this double character of a great navigator and a self-raised man

that we wish to sketch the leading features of his life.

2. James Cook was born of poor parents on the 27th October, 1728. The place of his birth was the village of Marston, not far from Stockton-upon-Tees, in the north riding of Yorkshire. Of his early education we only know that it could not have extended beyond the mere reading and writing acquired in a village-school; so that the labours of after life were required to supply the deficiencies of boyhood. His parents, apparently without consulting his inclinations, apprenticed him, when a boy of thirteen years of age, to a haberdasher, in the little fishing town of Staiths, near Whitby. His father, a farm-labourer of good character, no doubt considered that he had established his son in a re-

spectable line of life, and probably congratulated himself on the good prospects he had secured for him. But the natural bent of the boy's mind took a different direction; curiosity and the spirit of enterprise directed his thoughts to the sea, which daily lay stretched out before him—every white sail that disappeared below the horizon seemed to beckon him out into the mysterious distance, until at length the irksomeness of the business to which he was tied became almost insupportable. Still he manfully repressed his longings, and continued in the post selected for him by his parents until the death of his father, when, having his own career to choose, he could without breach of duty indulge his inclination for a seafaring life. He prevailed on his master to cancel his indentures, and bound himself as apprentice to a shipmaster of Whitby for a term of nine years. At length, then, his wishes were satisfied; he had embarked upon that wonderful sea, to which his eager eyes had so often turned. But the dream of pleasure could not have lasted long; the ship, in which he was employed, was engaged in the coasting coal-trade; and even to a hardy lad, gifted with more than an ordinary share of patience and power of endurance, the hardship of his new life must have been more difficult to bear than the easy though monotonous attendance at the counter. It was probably felt to be so by our young sailor; but the profession he had now embraced was his own choice, and to retreat from it because it demanded a hard service would have been unmanly: he persevered, therefore, steadily in his self-elected career, and in the course of a few years became master of a vessel.

3. For twelve or thirteen years he continued in this laborious service; and the wonder is, that, after so long a period, he was ever able to rise superior to a life into the coarse drudgery and coarser companionship of which he might be supposed to have been so thoroughly drilled. It was in the national service that the path of distinction was first opened to him, and a proper field supplied for the exercise of his great abilities. At the time he

entered upon this new sphere of action he was in the prime of manhood, with a body inured to hardship and exposure, and a mind of singular acuteness, well stored with practical experience in seamanship. His first ship was the 'Eagle,' a frigate commanded by Captain Hanmer, who was afterwards succeeded in the command by Captain Hugh Palliser. By steadiness and ability he was not long in gaining the notice and confidence of his commander, by whom he was placed on the quarter-deck, and whose friendship he retained through life.

4. In 1759, four years after joining the navy, being in his thirty-first year, he was advanced to the rank of master, and appointed to the 'Mercury' frigate, one of the squadron appointed to co-operate with General Wolfe at the siege of Quebec. During the operations of this celebrated campaign he piloted the boats of the squadron to the attack of Montmorency, conducted the disembarkation of the troops for the assault of the Heights of Abraham, and examined the channel, and laid down buoys for the guidance of the large ships in ascending the River St. Lawrence.

5. His promotion to the 'Northumberland,' the flag-ship stationed at Halifax, gave him the first respite from more laborious employment which he had enjoyed since his boyhood, and he instantly commenced turning it to good account. At an age when study is irksome to most, save the habitual student, he set earnestly and studiously to work to supply the imperfections of his early education. Owing probably to the practical experience of its utility, which he must have gained in the course of his surveys, geometry was the first subject to which he directed his attention. Having mastered Euclid's elements, he bent all the energies of a powerful mind to the study of astronomy and those other sciences useful in his profession; and attained such a knowledge of English literature as enabled him to write with perspicuity if not elegance. After this interval of comparative leisure, so well and profitably employed, Cook

returned home; but in the following year, his former captain, who had been created Sir Hugh Palliser, became governor of the colony of Newfoundland, and obtained for him the appointment of Marine Surveyor to the colony. It thus became his duty to survey the Gulf of St. Lawrence and the coasts of Newfoundland, and in this post he was occupied during the four following years.

6. It was now that the studies at Halifax began to bear fruit. An eclipse of the sun occurred while his position was favourable for observing it; and he communicated the results to the Royal Society of England. This proof of astronomical ability, added to his general character for perseverance and nautical skill, pointed him out as the fittest person to be intrusted with the charge of an expedition then in preparation at the suggestion of the Royal Society. The main object of it was, to observe in the Southern hemisphere the transit of Venus across the sun's disc—a phenomenon of great interest to astronomy—and generally to advance geographical knowledge by discoveries in the unexplored regions of the Pacific Ocean. Cook was appointed to the command with a commission as Lieutenant; and Mr. Green and Mr. (afterwards Sir Joseph) Banks, two gentlemen of scientific reputation, accompanied him, the one as astronomer, and the other as naturalist to the expedition. On the 23rd August, 1768, they sailed from Plymouth in the bark 'Endeavour,' of three hundred and seventy tons, a vessel, which Cook had himself selected, as best adapted for the service contemplated.

7. We have now come to that period of Cook's life upon the occurrences of which his fame rests. We have traced his career in his enterprising and determined boyhood; we have seen him rise steadily in an honourable profession by energy and perseverance; and now, in his fortieth year, we find him marked out by his reputation for the command of an expedition, the successful conduct of which has made his name

famous in the annals of maritime discovery. The 'Endeavour' doubled Cape Horn and anchored at Tahiti on the 11th April, 1769; this island (better known as Otaheite) having been previously fixed upon as the best place for the transit observations. This first important object of the expedition was successfully accomplished, and, on the 13th July, Cook quitted the island to prosecute his voyage for the purpose of discovery. During the prolonged stay of the 'Endeavour' the gentle and harmless natives had been treated with great judgment and kindness, while discipline was carefully preserved amongst the crew, so that the whole period passed without a single instance of outrage or complaint. Indeed, humanity in the treatment of inoffensive savages forms a pleasing feature in Captain Cook's character. After spending a month amongst a newly-discovered group of islands and islets, to which he gave the name of the Society Islands, he proceeded in search of a supposed great southern continent.

8. On the 6th October, the 'Endeavour' arrived in sight of land, which was supposed, at first, to be that previously visited by Tasman in 1642, and called by him New Holland. It proved, however, to be a new discovery, and received from Cook its present name of New Zealand. At these islands the expedition found ample occupation for six months, the commander making a survey of the islands, while the equally indefatigable Banks was enriching the field of Natural History by his diligent researches. From this place it was Cook's intention to proceed to New Holland, which he purposed visiting, and then returning to Europe by the Cape of Good Hope. An accident, however, retarded his progress, and nearly proved fatal to the expedition. Proceeding along the coast he entered Botany Bay, so named by Banks from the variety and luxuriance of its vegetation. After navigating and laying on a chart the eastern coast of New Holland, for a distance of more than 1300 miles, and miraculously escaping a thousand hidden perils, the ship

struck on a coral reef. After lightening her as much as possible, she was at length got off, a fothered sail, that is one thickly padded with oakum and other soft substances soaked in tar, was drawn under her keel and passed over the damaged part, and the leak was in this manner sufficiently stopped to admit of her reaching the coast. Fortunately a suitable harbour was at hand, at the mouth of what is now called Endeavour river, and here the vessel was laid aground. On examining the bottom, it was discovered how providential their escape had been, and to what a singular circumstance the preservation of the ship was owing. A large fragment of coral which, in working its way through the bottom had broken off from the rock, was found still sticking in the planking, and closing the aperture it had made. Had it dropped out when the vessel came off the reef, nothing could have saved her from foundering.

9. After months of hard labour, the 'Endeavour' was once more in a condition to prosecute her voyage; and passing round the northern extremity of Australia through Torres Straits, reached the Dutch settlement of Batavia. Proceeding homewards by the Cape of Good Hope, Cook reached England and anchored in the Downs, on the 12th June, 1771, after having circumnavigated the globe, and effected discoveries, the beneficial results of which, important as they now are, have not yet received their full development.

LESSON VIII.

THE LIFE OF COOK—*continued.*

1. THE interest previously excited by the successful voyages of Byron, Wallis, and others in the same hemisphere, was greatly increased by the accounts furnished by Cook. In addition to the discoveries actually made, his voyage corrected the erroneous opinion formerly entertained, that New Guinea and New Holland formed portions of one great continent;

and proved that, if the supposed great southern continent existed at all, it must be to the south of the 40° of S. latitude. This was, however, as regards the last point, but a negative result; and a positive elucidation of the question was considered of sufficient importance to authorize another expedition for the express purpose of exploring the southern regions.

2. Two ships, the 'Resolution' and 'Adventure,' were accordingly fitted out, and the command given to Cook, who for his previous services had been raised to the rank of Master and Commander. On the 13th July, 1772, Captain Cook departed from Plymouth, on his second voyage, amply furnished with all those necessaries and comforts for the health of his men which experience suggested, and which were calculated to contribute to the safety of the expedition. His instructions were to circumnavigate the globe in a high southern latitude, and approach as near as possible to the South Pole. After many unsuccessful attempts to penetrate the icy barriers which have, up to the present time, guarded the Pole from human eyes, the 'Resolution,' in January 1774, reached her extreme point, in lat. 71° 10′ S., and long. 106° 54′ W.; but, although many months were spent in the search, no southern continent was to be found. Returning northward, Cook examined the intertropical portion of the Pacific, visiting Easter Island, the Marquesas, the Friendly and Society Islands, and the New Hebrides; and discovering a large island, to which he gave the name of New Caledonia. From thence he proceeded to New Zealand, and after spending some time in friendly intercourse with the natives, quitted these islands on the 10th November to explore that portion of the Southern Ocean lying between the 43rd and 56th parallels of latitude. Having traversed this he rounded Cape Horn, and thus re-entered the Atlantic. The only discovery consisted of the desolate island to which he gave the name of Sandwich Land, in honour of Lord Sandwich, who was then at the head of the Admiralty.

3. "I had now," says Cook, in his Journal, "made the circuit of the Southern Ocean in a high latitude, and traversed it in such a manner as to leave not the least room for there being a continent, unless near the Pole, and out of the reach of navigation."

The 'Adventure' had long before this time parted company, and a jaded crew and deficiency of provisions hastened Cook's determination to shape his course homewards; he, therefore, sailed for the Cape of Good Hope, and, quitting it after a short stay, reached England on the 30th July, 1775. During this prolonged voyage there had been an extraordinary freedom from accident in the 'Resolution.' Not a mast or yard had been lost or sprung; and such had been Cook's watchfulness and attention to the health of his crew, that during the whole period they were at sea he lost only one man by disease. Scurvy, that scourge of seamen, which had committed such ravages amongst the earlier navigators, had been completely averted by the wise precautions taken against it; and all future commanders of expeditions were taught by Cook's successful example, that by laying in a sufficient stock of antiscorbutic stores, especially lime-juice and vinegar, and strict attention to the cleanliness of the men, and ventilation and dryness of the ship, protracted voyages need not be necessarily accompanied with loss of life from disease.

4. On his return from this voyage Cook was rewarded with the post of a captain of Greenwich Hospital, and had earned a reputation of which he had just reason to be proud; but he was not a man to recline on his laurels while there were others to be gathered. The following year he volunteered his services for the command of a new expedition at the opposite extremity of the globe. He had just examined the neighbourhood of the South Pole, but the North Polar region remained a mystery. Many vain efforts had been made to penetrate from the Atlantic to the Pacific Ocean, and effect the celebrated North-west passage, for the discovery of which the large reward of 20,000*l.* had been

offered by Government: it was now thought, and McClure has recently confirmed the belief, that an attempt in the opposite direction might prove more successful. The 'Resolution' and 'Discovery' were fitted out, and furnished with all that experience and science could suggest for the prosecution of the search.

As the vessels had necessarily to proceed in the direction of Cook's recent discoveries in the tropical Pacific, they were supplied with cattle and sheep, to be put ashore in the different islands, and many a distressed crew has since reaped the benefit of this wise proceeding. On the 12th July, 1776, the ships quitted Plymouth, and Cook gazed for the last time on his native shores. When the expedition reached the Pacific, the season of 1777 was too far advanced for an effort to be made in the direction pointed out in his instructions; he, therefore, employed the time that would otherwise be lost in a careful examination of the Friendly Islands, and added considerably to our geographical knowledge of the innumerable islands constituting this archipelago. When the proper season arrived, he quitted these peaceful regions, and shaped his course for Behring's Strait. On the 17th of January, while on his northward voyage, an extensive group of islands was discovered; to these Cook gave the name of the Sandwich Islands.

5. The coast of North America was reached early in March; and the ships needing repairs before entering upon the difficult navigation of the Arctic Seas, Cook put into Nootka Sound for the purpose of effecting them. After this necessary precaution, he proceeded on his voyage, and early in the month of August entered the Channel which separates Asia and America; on the 18th he reached the point of land still known by the name then given to it, Icy Cape, and continued until the end of the month, vainly attempting to penetrate eastward. Finding then that the season was far advanced, and having to contend with continual storms and adverse winds and currents, he was reluctantly

compelled to desist from the attempt to advance farther. On his return he made an examination of the coasts of Asia and America, and visited Cape Tuski, where he tried in vain to induce the natives to approach the ships; he then sailed for the Sandwich Islands, intending to resume operations the following spring. It was during the stay of the ships at these islands, that an event occurred which caused a sad termination to the hopes and exertions of the expedition.

6. On their first discovery, the largest and most important island of the group had not been noticed. Cook resolved, during his winter sojourn, to supply this omission, and sailed for Owhyhee. Here the strange visitors were received with apparent confidence and kindness. For several weeks the most amicable feeling seemed to prevail, and Cook deemed the discovery of so beautiful and interesting an island no small compensation for the disappointment he had met with in his northern route. While the ships were lying in Karakakova Bay, however, disputes, trifling enough in their nature, arose from the habit of pilfering, common to most of the natives of the South Sea Islands. At first this dishonesty did not cause any uneasiness: the articles taken were of little value, and the crew had been accustomed to similar losses in the other islands; but in February, 1779, the islanders, no longer satisfied with petty theft, seized one of the boats belonging to the 'Discovery,' having first by their numbers compelled her crew to swim for their lives to a rock at some distance. This event caused great anxiety to the commander, for it became manifest that if some measures were not taken to resent the attack, the natives would plume themselves upon the advantage they had gained, and resort to further acts of insolence and robbery. He immediately ordered that all natives on board the ships should be sent ashore. The following night the Discovery's cutter was stolen; and upon this being made known to him, Cook ordered a party of marines to be got ready to accompany him on shore, and directed that until

he returned no canoe should be allowed to leave the Bay. His intention was to seize the king, and detain him as a hostage until the stolen articles were restored.

7. At 7 o'clock on the morning of the 14th of February, Captain Cook left the ship in the pinnace, accompanied by Lieutenant Phillips of the marines and nine privates, and on his way fell in with the launch, which he took with him. On reaching the landing-place, he marched with the guard of marines to the village of Koroowa, where the king resided. Here he was received with the usual marks of respect; and the king, without hesitation, agreed to accompany him, with his two sons, on a visit to the 'Resolution.' From this determination, however, he was soon afterwards moved by one of his favourite wives, abetted by two of the chiefs who accompanied her. A crowd began to assemble, and as some firing of guns was heard from the bay, affairs soon assumed a serious aspect. Notwithstanding the feeling of hostility manifested by the natives, Cook for a time, persevered in his endeavours to induce the king to accompany him; but finding the tumult increase, he desisted, and proceeded towards the landing-place. Scarcely had he left the place, when news arrived that a chief had been killed in a canoe, by a shot from one of the English boats, while the canoe was attempting to leave the harbour. This roused the whole population to fury. Men and women equipped themselves in their war-mats and seized their weapons. A warrior advanced in front of the crowd, having in one hand a stone, and in the other a long iron spike, which he flourished in defiance. He was cautioned not to come nearer the small party, now retreating on the boats. Impunity only made the savage more daring, and as he still advanced upon them Captain Cook fired one of the barrels of his gun, loaded only with small shot. The war-mat resisted the charge, and added to the confidence of the islanders. The tumult increased, stones were thrown, and an attempt made to stab Lieutenant Phillips; Cook then fired his

remaining barrel loaded with ball, and killed one of the ringleaders. This was followed by a general attack on the part of the islanders; and, although the marines and seamen in the boats discharged their muskets, the party on shore was closed upon before they had time to reload. A confused struggle ensued, in which Cook was mortally wounded. While his face was towards the enemy they abstained from attacking him, but as he turned upon the beach to order the approach of the boats, he was stabbed from behind, and fell on his face in the water.

8. Thus unhappily perished this great navigator on the distant shores of an island, whose sands his had been the first European foot to press. His mutilated remains were after some time recovered, and committed to the deep, where they rest in no inappropriate sepulchre beneath the still waters of the Pacific. A universal feeling of regret was excited by the tidings of his death, for he had gained the esteem and respect of his officers and men, and a reputation amongst his countrymen unsurpassed by any seaman of his age.

JOSEPH ALLEN.

LESSON IX.

THE SAILOR'S GRAVE.

THERE is, in the lone, lone sea,
  A spot unmarked, but holy,
For there the gallant and the free
  In his ocean bed lies lowly.

Down, down beneath the deep,
  That oft in triumph bore him,
He sleeps a sound and peaceful sleep,
  With the wild waves dashing o'er him.

He sleeps—he sleeps, serene and safe,
  From tempest and from billow;
Where storms that high above him chafe
  Scarce rock his peaceful pillow.

The sea and him in death
They did not dare to sever;
It was his home when he had breath,
'Tis now his home for ever.

Sleep on—sleep on, thou mighty dead!
A glorious tomb they've found thee,
The broad blue sky above thee spread,
The boundless ocean round thee.

No vulgar foot treads here,
No hand profane shall move thee,
But gallant hearts shall proudly steer,
And warriors shout above thee.

And though no stone may tell
Thy name, thy worth, thy glory,
They rest in hearts that loved thee well,
And they grace Britannia's story.

* * *

LOOK ALOFT.

In the tempest of life when the wave and the gale
Are around and above, if thy footing should fail,
If thine eye should grow dim, and thy caution depart,
"Look aloft," and be firm, and be fearless of heart.

If the friend, who embraced in prosperity's glow,
With a smile for each joy, and a tear for each woe,
Should betray thee when sorrows like clouds are arrayed,
"Look aloft" to the friendship which never shall fade.

Should the vision which hope spreads in light to thine eye,
Like the tints of the rainbow, but brighten to fly,
Then turn, and, through tears of repentant regret,
"Look aloft" to the sun that is never to set.

Should they who are dearest, the son of thy heart,
The wife of thy bosom in sorrow depart,
"Look aloft" from the darkness and dust of the tomb,
To that soil where "affection is ever in bloom."

And oh! when death comes in his terrors, to cast
His fears on the future, his pall on the past,
In that moment of darkness, with hope in thy heart,
And a smile in thine eye, "look aloft," and depart!

JONATHAN LAWRENCE.

Geology.

BY J. BEETE JUKES.

LESSON I.

MINERALS AND ROCKS.

"Thou, Lord, in the beginning, hast laid the foundation of the earth."

1. All the visible creation is often said to be divided into three kingdoms—the animal, the vegetable, and the mineral. According to this classification everything which is not an animal or a vegetable, or did not at one time form part of an animal or a vegetable, must be a mineral. If, however, we attempt to use the word strictly with this meaning, we should be compelled to class the water we drink, and the air we breathe, as minerals. On the other hand we should find that many things which really had once formed parts of animals and vegetables were, strictly speaking, minerals. Thus we can extract the mineral lime out of the bones and shells of animals, while burnt wood or charcoal is, in reality, almost pure carbon—the same mineral substance which is the principal component of coal and jet, and which occurs quite pure in the diamond. It is clear, therefore, that this threefold division of the creation is not a strictly accurate one, and that if we wish to speak with correctness and precision, which in matters of science is always necessary, we must adopt some other mode of classification.

2. In the old systems of philosophy we commonly read of the four elements—earth, air, fire, and water; and all things were formerly supposed, fluid or solid, living or dead, to be made up of these four elements. Now, by an "element" it is plain that we mean, or ought to mean, one primary substance, which has nothing mingled with it, or combined with it, in any way whatever, but is a simple substance of one only sort. Modern philosophers, however, are able to extract many sorts of substances out of earth; they know many substances all equally inflammable, or, in other words,

fire can be made of many different things; and air and water are themselves each divisible into two gases, which can be shown by the chemist to be different substances.

3. It is plain, then, that none of these four things can be elements. There are, however, many things which no art of man has yet succeeded in decomposing, or dividing into two or more component parts, and which, therefore, we are obliged to look upon, for the present at least, as really elementary substances. There are more than sixty of these simple substances or elements. First of all, there are all the pure metals, such as gold, silver, iron, lead, copper, tin, antimony, manganese, zinc, and a great many others which do not ordinarily occur. Secondly, there are six substances, called sulphur, phosphorus, carbon, silicon, boron, and selenium; and lastly, there are seven substances, which, when pure, are always found in the state of gas or aeriform fluid—these are called oxygen, hydrogen, nitrogen, iodine, chlorine, bromine, and fluorine.

4. Now, of these elementary bodies it would be quite proper to consider all those which occur in a solid form as minerals, and even those which occur originally as gases, when they combine with these other simple mineral substances, become solid, and thus enter largely into the structure of compound minerals. If we were to follow up this subject more completely, we should come to consider certain simple minerals as the basis or foundation, as it were, of all creation; existing in everything, more or less combined with the gaseous substances mentioned above. The chemist finds that all animals, and all vegetables, as well as minerals, are made up of solid, earthy, or metallic matter, variously combined with those gaseous elements. Neither is it absolutely essential to our idea of a mineral substance that it should be solid; mercury or quicksilver, for instance, is always seen fluid, except in the intense cold of an arctic winter; lead or iron, again, do not cease to be minerals when they are melted. We might then, perhaps, even go the length after all of calling water a

mineral, which is solid when it is frozen into ice, fluid when it exists as water, and gaseous when, by the application of heat, it becomes converted into steam. This appears, at first, as an extreme view; but water is now generally called and treated as a mineral by mineralogists, though we cannot speak of air under that term.

5. It would be better, perhaps, to consider nature as divided into two kingdoms, which we may call the organic and the inorganic. Everything that has life, whether it be animal or vegetable, is made up of one or more organs, by means of which the processes of life, such as circulation and digestion, are carried on; things destitute of life, on the contrary, have need of none of these organs, whether they be tubes, cells, or vessels, for the continuance of their existence, and they are therefore called inorganic. Now of inorganic things, we may say that all those which are either metallic or earthy are minerals, or belong to the mineral kingdom. There is, however, another and more restricted meaning still for the word mineral, that is adopted when we consider minerals as forming the object of a science called mineralogy. In this sense a mineral must be a certain definite substance, being made always of the same ingredients, nearly in the same proportion, and having nearly always the same properties and qualities. It will make our meaning clearer, perhaps, if we take as illustrations the two common mineral substances, limestone and sandstone.

6. Limestone is strictly a mineral: it is made of lime combined with a certain proportion of carbonic acid. The ordinary method of procuring lime is by putting pieces of limestone into a kiln with pieces of coal or wood, and setting the latter on fire; the heat then drives out the carbonic acid, which escapes in the form of a gas; the same gas, in fact, that extinguishes flame or life, and when accumulated in mines is called choke-damp. All limestone, whether it be soft, as chalk, or hard, as statuary marble, when heat is applied

to it gives off this gas, and the remainder that is deprived of it is found to be lime, or "quick-lime" as it is called. The scientific designation of limestone, therefore, is "carbonate of lime," and it is always made of these two substances, "lime" and "carbonic acid," in nearly always the same exact proportions. Sandstone, on the other hand, has no definite ingredients; it is made up of grains of sand, compacted together, but these grains may be made of all sorts of substances. Some of them even may be little fragments of limestone or carbonate of lime, others of other minerals called quartz, felspar, hornblende, mica, &c., of either one or of any two or three, or all of these minerals mingled together in any way, and in any quantity. When we speak of "sandstone," therefore, by itself, nobody knows what may be the ingredients it is made of, as they do when we speak simply of "limestone." It is true that they are both "stones" and both rocks; but while sandstone is only a rock, limestone is not only a rock but a mineral also, in the restricted meaning we are now speaking of as forming part of the science of mineralogy.

7. Now, when we use the word rock here we give to that also a particular meaning, slightly different from the common one, inasmuch as we do not necessarily mean a hard substance. In geology (or lithology, as we may call the science of rocks and stones), under the general term "rock" we designate any considerable masses of earthy matter whether they be hard like granite, or soft and yielding like clay, sand, or mud. It is a sense in which we are obliged to use the word from default of any other term. There is yet another distinction we must point out between a "mineral" and a "rock," and that is, that a mineral, in addition to its having a definite chemical composition (or being always made of the same ingredients in the same proportions), either has, or is capable of assuming, a certain definite form called a crystal.

8. If we return to limestone again, and were to take a piece of it, say a piece of chalk, or a piece of statuary

marble, it would be quite possible for us in a chemist's laboratory to dissolve it entirely into certain fluids, and then by putting that fluid through certain processes to get it back again, not as a dull stone, but as a clear transparent crystal of a certain regular shape. These crystals of carbonate of lime are found in the veins of many limestone rocks in great abundance, and some limestones are entirely made up of them, consisting of a complete assemblage of small crystals, interlaced and entangled together. In using the word crystal, in our common conversation, we are apt to think only of a clear transparent substance; but it is not the transparency that is the essential idea of the crystal, it is the regularity of form. All minerals, even all metals, when subject to the same processes of reduction to a fluid state, on reconsolidation, under similar circumstances, assume exactly the same forms; but while some of them may be transparent, others are not so. A very common mineral, for instance, called iron pyrites, or sulphuret of iron, being composed of iron and sulphur, has, for the primary or unmodified form of crystal, a cube. They are little solid squares like brass or gold in appearance, and are found very abundantly in many rocks. This assumption of a regular form, then, when placed under favourable circumstances, is an essential peculiarity of a "mineral" in our present restricted sense. And no substance is, properly speaking, a mineral, as forming one of the objects of the science of mineralogy, that has not this property.

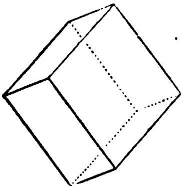


Fig. 1.

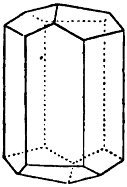


Fig. 2.

9. Although each mineral has one simple crystalline form, yet that form admits of many modifications, according to the ways in which it may be split or "cleaved;" and the several modifications may be combined together in many ways, so

that each primary form has an almost endless variety of secondary forms springing out of it. Figs. 1 and 2 represent two crystalline forms assumed by the mineral called carbonate of lime, and figs. 3 and 4 two of those of iron pyrites. "Rocks," on the other hand, have none of this regularity of form, but occur in blocks of all shapes, sizes, and dimensions, or when they do assume a regularity of form, that form is essentially different, and produced in a different way from that by which a crystal is formed.

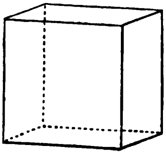


Fig. 3.

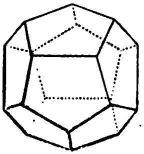


Fig. 4.

10. We can now give a definition of these two words "mineral" and "rock" such as will enable us to understand exactly what is meant by them, when we meet them in books of science. A "mineral" is a metallic or earthy substance, having a definite chemical composition, and the power, when quite pure, and passing from a fluid to a solid state, of assuming a definite, regular form or crystal.

A "rock" is an earthy substance made up of one, two, or more minerals, which may be in any condition of purity, or of any size and shape, and occur, even in different parts of the same mass, in all possible varieties of proportion and condition. It is, however, quite true that in some cases a "rock" may be made up entirely of one "mineral" in a state of perfect purity, and either "crystalline" or "compact;" in this case the substance is both a true "mineral," forming one of the objects of mineralogy, and also a "rock," forming one of the objects comprehended in the science of geology, or of that part of it which we may call lithology.

11. It is possible that what has been here written may seem a little dry and difficult to understand. Let no one, however, be discouraged on that account. It will be much easier for us in the end, if we have a clear explanation at the beginning; and if any one of my young readers shall find it at first impossible to comprehend

this explanation, perhaps the best way will be to read on to the end of this chapter, and then to read the beginning over again; and then it may be clearer. Sometimes when we are beginning a new subject of study, our progress is impeded by fancying that the first explanations have a deeper meaning than appears upon the surface of them, and we are apt to stop and puzzle ourselves by trying at once to penetrate into the heart of the matter. This is usually impossible; all knowledge must be acquired by degrees, by slow step after step forward; and it is often better to proceed a little way, and then begin again and retrace our steps, by which means we make ourselves thoroughly masters of the direction and the course on which we are proceeding. Having, then, thus given you a few notions of what "minerals" and "rocks" are, wherein they are alike, and how they differ, I will proceed to tell you something about their several kinds and varieties.

LESSON II.

MINERALS.

MINERAL TREASURES.

"Nor to the surface of enlivened earth,
Graceful with hills and dales, and leafy woods,
Her liberal tresses, is thy force confined:
But, to the bowelled cavern darting deep,
The mineral kinds confess thy mighty power.
Effulgent, hence, the veiny marble shines;
Hence Labour draws his tools: hence burnished War
Gleams on the day; the nobler works of Peace
Hence bless mankind; and generous Commerce binds
The round of nations in a golden chain.
  Th' unfruitful rock itself, impregned by thee,
In dark retirement forms the lucid stone.
The lively Diamond drinks thy purest rays
Collected light, compact.
At thee the Ruby lights its deepening glow
And with a waving radiance inward flames.
From thee, the Sapphire, solid ether, takes
Its hue cerulean; and of evening tint,
The purple-streaming Amethyst is thine.

With thy own smile the yellow Topaz burns;
Nor deeper verdure dyes the robe of Spring,
When first she gives it to the southern gale,
Than the green Emerald shows. But, all combined,
Thick through the whitening Opal play thy beams;
Or, flying several from its surface, form
A trembling variance of revolving lines,
As the site varies in the gazer's hand."—THOMSON.

1. MINERALS, strictly so called, have been classified in various ways; for instance, they may be classed according to the forms of their crystals, or according to their chemical composition, or according to their external or internal properties, or on a system founded on a consideration of all these characters. To attempt to describe all these classifications would be to write a treatise on Mineralogy. I shall, therefore, refer you to such works for future study, and not regard in what I am about to say any very strict scientific system. There are, however, two minerals, the composition of which, in great part, governs that of many others, and these are Silica and Alumina. There is a substance which is obtainable by the chemist, though never found naturally pure, this is the simple substance or element Silicon. It looks like a dull, brown powder, when obtained in the laboratory. When heated with oxygen gas the two combine to form silicic acid, or the earth silica, the purest form of which is the mineral quartz. This may be considered the essential element of sand. Thereis also a pure metal called Aluminium, which can be produced in the laboratory, though not found naturally: and this, when similarly combined with oxygen, makes the earth alumina. This may be called the essential ingredient of all clays, it is also one of the principal ingredients of alum, whence it derives its name.

Having premised this much we will describe very briefly a few minerals, beginning with those striking and glittering things called gems, which have, in all ages, been the precious toys of men and women.

2. GEMS.—Brilliant gems, or precious stones as they are called, are of various kinds.

The *diamond*, figs. 5 and 6, is pure carbon; to speak roughly it might be called crystallized charcoal, except that in charcoal there is ordinarily some impurity in the shape of other earthy matter besides pure carbon. It is possible to inflame and burn up a diamond by applying an intense heat to it. It is, indeed, believed to be of vegetable origin; perhaps a piece of fossil gum that has passed into a perfectly crystalline state. The diamond is the hardest substance in nature, and will scratch all other minerals.

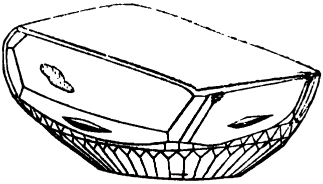


Fig. 5.

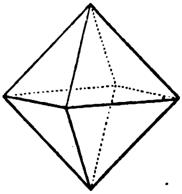


Fig. 6.

The above figure 5 represents the celebrated Koh-i-noor, or mountain of light, in possession of Her Majesty.

3. The mineral by which the diamond is often imitated is called *rock crystal*, or *quartz;* though hard enough to scratch glass, it is yet much softer than the diamond. Crystals of quartz (fig. 7) occur abundantly in the veins and crevices of many rocks. When coloured with certain impurities, such as slight metallic and earthy infusions (so to speak), it assumes various forms, and is known under many names, producing stones, more or less used for ornamental purposes, and to which more or less value is attached, though they can hardly be called precious stones. These are—amethyst, a purple or bluish crystal of quartz; false topaz, a yellow variety; cairngorm, a brownish or smoky one; chalce-

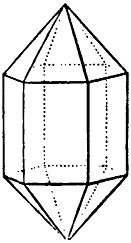


Fig. 7.

dony, a waxy-looking white opaque variety; cornelian, a reddish chalcedony; agate, a variegated kind; onyx, where the colours are arranged in bands; and cat's-eye, in which the chalcedony is partly transparent and like opal. Other varieties of quartz are, jasper, a dull red, brown, yellow, or green; bloodstone, deep green with blood-red spots; and Lydianstone or touchstone, which is velvet-black, and is used by goldsmiths for trying gold and silver on, by rubbing them against it, and observing the colour of the streak.

Opal is a variety of quartz which contains a certain amount of water combined with it. By "water combined with it," I do not mean that there is actual water existing, even in the minutest drops, in the mineral, but that it is assimilated into its substance, and wholly compounded with it, forming together with quartz the solid mineral opal; some varieties of which, from their semitransparency and beautiful play of colours, are very highly valued, and take rank among the precious stones.

4. *Sapphire*, fig. 8, is a beautiful gem, varying in colour from blue to red, brown, yellow, grey, and even white; it has sometimes a lustre like opal, but it contains no silica or quartz, and is pure alumina crystallized. Corundum, or emery, is a grey or dark kind of sapphire; red sapphire is the Oriental ruby, the yellow kind is sometimes called topaz, the green oftentimes emerald, and the violet is called amethyst. In hardness, sapphire is next to the diamond.

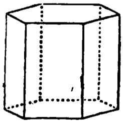


Fig. 8.

Ruby, the true ruby or spinel, is a crystalline compound of alumina and magnesia; its colour is deep red, but it sometimes passes into other shades of red, and even into blue, green, yellow, brown, black, and white. In hardness it comes next below sapphire, which it resembles in its primary crystalline form.

The *emerald*, and *beryl*, are only varieties of the same thing: they are compounds of alumina, with a substance called glucina, together with a large proportion of silica. The rich green varieties are true emeralds, those of other colours are called beryls. These emeralds are not to be confounded with the green sapphires which have been just mentioned, and which are only called so erroneously. In hardness this gem is slightly inferior to the ruby. It has the same primary crystal as the sapphire.

5. *Topaz*, that is, the true topaz, is a compound of silica and alumina, with the substance called fluorine. It is generally yellow, but sometimes blue or green. In hardness it is equal to ruby; its primary crystal is shown in fig. 9.

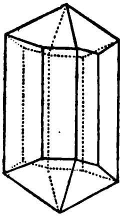


Fig. 9.

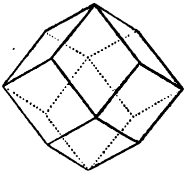


Fig. 10.

Garnet, the primary crystal of which is shown in fig. 10, is a very compound mineral, made of different combinations of silica with alumina, lime, iron, and manganese. Precious garnets are dull red and transparent; but opaque garnets of various hues are very abundant in rocks, such as gneiss and mica slate. Garnet is not so hard as quartz or rock crystal; carbuncle is a kind of garnet.

6. The next principal class of true minerals which we will briefly examine are those called—

Earthy Minerals. — *Sulphur* is one of the few simple substances that is found in nature, pure or uncombined, in considerable abundance. It also occurs combined with many other substances, especially in the ores of many metals. It is found pure (or *native*, as it is called) about many active or extinct volcanoes. It is used largely in the manufacture of gunpowder, in making sulphuric acid or oil of vitriol, and in many processes of the arts and manufactures.

7. *Potash* and *soda* are the oxides, or combinations with oxygen (the "rusts" as it were) of two metals that are never found naturally uncombined, namely, potassium

and sodium. Potash and soda both occur native, but they are usually combined with other substances, which are themselves similar combinations of simple substances with oxygen; *nitre*, for instance, or saltpetre, is a combination of potash and nitric acid, or is a nitrate of potass. *Glauber salt* is a combination of soda with sulphuric acid, or a sulphate of soda. *Common salt*, again, is formed by the combination of soda with hydrochloric acid or muriatic acid, as it is sometimes called. Nitre is found in certain soils in Spain, Egypt, and Persia, and in minute needle-shaped crystals in the crevices, or on the surface of rocks; it is also procured artificially. Common salt is either procured from the waters of the sea, or from brine-springs that rise in many countries; or it is mined or quarried from great beds of "rock-salt" that exist in the rocks of some regions. When found thus in the earth it is usually embedded in red marl or clay, and often associated with other minerals. At Northwich, in Cheshire, are one or two beds of rock-salt, generally of a dull reddish colour, at a depth of more than one hundred yards. In one of these a huge chamber has been excavated, twenty or thirty acres in extent, and twenty-five feet in height, supported by great pillars that have been left to prop up the roof. To see this great chamber, and these many pillars of salt, lit up as it has been sometimes by two or three thousand candles, and to hear the low rumbling thunder-like reverberations from the roof, caused by the blasting of the rock at the far end of the mine, is one of the many underground wonders of England, well worthy of a visit.

8. *Heavy-spar*, or sulphate of baryta, is the heaviest of all the earthy minerals. It occurs in considerable abundance in many veins of the rocks, either compact or in beautiful tabular crystals. (fig. 11.)

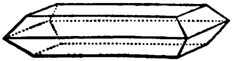


Fig. 11.

Of minerals composed of *lime* and *magnesia* I have already spoken of *carbonate of lime* or limestone; there is also *gypsum*, which is sulphate of lime, the crystalline form of which is called selenite. Fig. 12 shows the primary crystal of selenite. Alabaster and plaster of Paris are made of gypsum. *Dolomite* is made of carbonate of lime and carbonate of magnesia; when highly crystallized it is often called bitter spar, when more compact, magnesian limestone. *Fluor-spar*, the beautiful mineral called "blue-john" in Derbyshire, is fluorate of lime; it is used principally for ornamental purposes. Its primary crystal is the cube like fig. 3. Of minerals, of which alumina is the principal essential ingredient, we may enumerate, first, *alum*, of which there are many varieties, all combinations of alumina and sulphuric acid, together with other matters. Common alum is a sulphate of alumina.

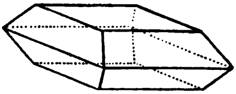


Fig. 12.

9. The most numerous and important class of minerals of this kind, however, are the silicates of alumina, those in which silica and alumina combined form the principal ingredients. Of these, one numerous family are the minerals called *zeolite*; of which there are at least twenty species; they are found abundantly in igneous rocks. Another family are the *feldspars*, of which there are twenty or thirty species. Common feldspar is generally white or flesh-coloured, in oblong opaque crystals (fig. 13), having a satiny lustre. It is one of the principal constituents of granite. Labrador feldspar is semitransparent, and has a beautiful play of colours, green and blue shot with red.

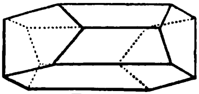


Fig. 13.

The *garnet* family, besides precious garnet, includes a group of five or six minerals, of which *epidote* is one, a green mineral, occurring frequently in many igneous rocks. The *mica* family has several species, the most common of which are characterized by a metallic lustre, and by splitting into flexible and elastic plates, that in Russia and elsewhere have been used instead of window-glass, or instead of horn for lanterns. Mica varies in colour from black, to yellow, green, and white. This mineral is likewise one of the constituents of granite.

10. In addition to the silicates of alumina, as these compounds are called, there are some other minerals, which are silicates of lime and magnesia. Of these, talc or soapstone is a silicate of magnesia, very like mica in appearance, from which it differs in its plates being not elastic. It also occurs compact or massive, so as not to split into plates. *Meerschaum*, of which the bowls of pipes are made, is a silicate of magnesia, found in the veins and crevices of rocks in Asia Minor, Greece, and other places.

Serpentine is a very handsome mineral, variegated green, black, and red. It occurs in large masses, and is used as a marble for ornamental purposes. True serpentine is a silicate of magnesia, containing water. *Chlorite* is likewise a green mineral and is a silicate of alumina and magnesia, it occurs abundantly in some rocks.

11. *Augite*, or *Pyroxene* (fig. 14), a silicate of magnesia, with more or less of a silicate of lime, is of a green colour, sometimes light, sometimes dark, passing into brown or black. It is a very abundant constituent of some lavas and other kinds of igneous rock. *Hornblende* is a very similar mineral, both in composition and appearance, and only to be distinguished from augite by its minuter characters. It likewise enters very largely into the composition of many igneous rocks. To these two species, augite and hornblende, belong the varieties called *Diallage*, *Hypersthene*, *Actinolite*, and *Asbestos* or *Ammianthus*, of which uninflammable cloth is made, and some kinds of which are called "Mountain cork," or "Mountain leather."

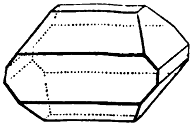


Fig. 14.

Olivine, or *Chrysolite*, is likewise a silicate of magnesia, the latter term being applied to the finer and more transparent crystals. This is likewise found abundantly in the volcanic and igneous rocks.

All these silicates of magnesia agree in a tendency to a green colour, and in being more or less readily fusible. They may all be easily melted by the heat of the flame of a blowpipe.

LESSON III.

METALLIC MINERALS.

"Surely there is a vein for the silver, and a place for gold, when they find it." "Iron is taken out of the earth, and brass is molten out of the stone."

"Hail, adamantine Steel! Magnetic lord!
King of the prow, the ploughshare, and the sword!
True to the pole, by thee the pilot guides
His steady helm amid the struggling tides,
Braves with broad sail the immeasurable sea,
Cleaves the dark air, and asks no star but thee.
By thee the ploughshare rends the matted plain,
Inhumes in level rows the living grain;
Intrusive forests quit the cultured ground,
And Ceres laughs, with golden fillets crowned.
O'er restless realms when scowling Discord flings
Her snakes and loud the din of battle rings,
Expiring strength, and vanquished Courage, feel
Thy arm resistless, adamantine Steel!"

1. The next great class of minerals, one of which the practical use and value are familiar to us all, is that called the—

Metallic Minerals.—The metals and their various ores afford a great variety of minerals. Few metals, except gold and platina, are commonly found in a state of purity, or "native," as it is called by mineralogists. They are commonly combined either with oxygen or with some of the various acids, such as the sulphuric, the carbonic, or the nitric. I shall here content myself with briefly mentioning the usual way in which some of the most common metals occur.

2. *Tin* is commonly found as an oxide in an ore called

tinstone, or sometimes woodstone, from its looking like petrified wood, or stream tin, from its being found in rolled pieces in the beds of streams. It is also found in veins in granite and other rocks.

Iron is occasionally found "native" in rocks, but more frequently in meteoric stones that have fallen from the sky, and which almost invariably also contain a small proportion of the rarer metal "nickel," combined with sulphuric acid; iron makes the very abundant mineral iron pyrites, of which I have spoken before. Marcasite is a name for the white variety of *iron* pyrites. *Specular iron*, *Hematite*, *Micaceous iron ore*, are all oxides of iron, found in crevices or veins of many rocks; sometimes also these ores occur in beds, and occasionally in considerable abundance. *Spathic*, or *Sparry iron*, is a carbonate of iron, and of this the common *clay ironstone* is an uncrystallized earthy-looking variety; this is the most abundant of the ores of iron, and that from which the greatest quantity of metal is produced. It occurs in beds, either in regular seams or "floors" a few inches or a foot or two in thickness, or in layers of "balls" and "nodules." When several such layers occur very close together, they make a very valuable seam, and in mining districts each of them is commonly known by a particular name.

3. *Manganese* has never been found native. Black oxide of manganese is the most common ore of this metal, and it occurs very abundantly in many rocks, and in many different countries.

Zinc is not found native, the sulphuret of zinc called "blende," or "black-jack," is its most common ore; it occurs in many mineral veins, very abundantly in many countries.

Calamine is a carbonate of zinc, and likewise occurs in veins pretty abundantly.

4. *Lead* has been found native but rarely. Its most common ore is called *galena*, or sulphuret of lead, which occurs in veins or great cracks of the harder rocks, varying in width from a few inches to several feet, and being

commonly more or less nearly perpendicular. It often contains a slight proportion of silver, sometimes as much as 60 ozs. to the ton of lead. Carbonate of lead is a white earthy-looking mineral, which might be mistaken for carbonate of lime, or sulphate of baryta, at a hasty glance ; it was so mistaken formerly in Derbyshire, and thrown away as a "spar," until some one with a little knowledge of mineralogy pointed out its true value.

5. *Copper* is not unfrequently met with native, but not often in any considerable quantity. Its most common ore is *copper pyrites*, which look like iron pyrites, but may be known from that mineral by its being capable of being cut with a knife, which iron pyrites is not. It occurs in veins in the same way that lead does. *Red oxide of copper* also occurs pretty abundantly; and several other ores, among which must especially be mentioned *malachite*, or the *green carbonate of copper*, which occurs frequently in the upper parts of a vein, and seems to be the result of the decomposition of other ores, and the union of the metal with carbonic acid. This splendid ore is split into thin slices, and used for inlaying and ornamental work.

6. *Mercury* does exist in the native state, but its most usual ore is *cinnabar*, or sulphuret of mercury, a beautiful red-coloured ore, which is said to occur in beds in some slate rocks, but is also found in veins with other ores. There is also an *amalgam*, or mixture of mercury and silver, said to be found in Germany. Mercury has the property of instantly uniting with either gold or silver wherever they are brought into contact, and forming a compound with them called amalgam.

7. *Silver* is common, native, in small quantities; and in some places, as in Norway, magnificent blocks of native silver have been found weighing even as much as 5 cwt. Of the ores of silver found in veins in the rocks like other metallic ores, the most abundant are *silverglance*, or sulphuret of silver, *pyrargyrite*, called also ruby silver or black silver, stephanite or brittle silver ore, and *horn silver*, or chloride of silver. Much

silver is extracted from lead after that metal has been reduced from its ores.

Platinum is only found native or mingled with other rare metals, such as iridium, rhodium, and palladium. It is got principally in Russia; but small quantities are procured from many other countries. It is the heaviest of all metals except gold. Coins are made of it in Russia.

8. *Gold* is never found otherwise than native, though it often contains slight admixtures of silver or other metals. Its original site is almost invariably the veins of quartz, which are found so abundantly traversing all the harder rocks. It has, however, been washed out of these in large quantities by natural agencies, and has been and is now found among the superficial gravels, sands, and clays of nearly all countries that contain mountains of hard rock. The principal supplies of gold are now derived from washing these loose materials in Australia, California, and on the flanks of the Ural mountains. "Gold-mining" or extracting it by the aid of machinery from the hard veins in the solid rocks, is commonly not so profitable as "gold-washing" or resifting those broken materials which nature herself has crushed, powdered, and partly washed, and sorted by her own processes ready to our hands. Many other minerals besides quartz, and especially nearly all iron pyrites, contain minute quantities of gold, sometimes in sufficient quantity to pay for the expense of extracting it.

9. There are, in addition to the minerals already described, some other mineral substances which are met with in books on mineralogy, such as *amber*, *jet*, *bitumen* or *asphalt* or *naphtha*, *hatchetine* or *mineral tallow*, *elaterite* or *mineral caoutchouc*, and *coal*. None of these, however, are minerals in the restricted sense of the word we have spoken of before, being either organic compounds, such as gums, or other vegetable products, in a fossil state; or the products of the decomposition of animal and vegetable substances; or else, like coal, they are masses of organic matter,

sometimes, perhaps, animal, but much more often vegetable, mingled with more or less of earthy matter in every proportion, and buried in the earth by natural causes, where they have become subject to several chemical actions, and become more or less mineralized as it may be called. They are not, however, true or perfect minerals until, as in the diamond, they assume a crystalline form, and thus throw aside all trace of their organic origin and structure.

LESSON IV.

ROCKS.

1. I HAVE already spoken of the difference between a "rock" and a "mineral," when these words are used in a scientific sense. I will now briefly describe the principal kinds of "rock" in the same rough way in which I have sketched the various species of "minerals."

Rocks, however, must be first classified into several great divisions before their nature can be properly understood. Some rocks are of igneous origin, that is to say, they have once been melted by excessive heat, and have cooled down from that fused state into the condition in which we now find them. You will easily understand from what has been said before (p. 76), that rocks which have been thus made fluid will, on *consolidation*, be very likely to assume a crystalline structure; that is to say, the several minerals of which they are composed will have had a tendency each to assume that proper crystalline form which is natural to it. In examining the internal structure of most igneous rocks, we are able to detect the crystals of the several minerals that compose them, all interlaced and entangled one with the other, none, perhaps, having been able to assume their complete form, because they have all been interrupted by the simultaneous formation of their neighbours. It is this interlacing and locking together, as it were, of their crystalline particles that render most igneous rocks so hard and so difficult to break. This hardness and toughness will, however, depend for its degree on the relative hardness of the different minerals, as also will the weathering properties, or power of resisting the action of air or water.

The following are the principal:—

2. Igneous Rocks.—*Granite* is a crystalline compound of three minerals—feldspar, quartz, and mica. Of these three minerals, quartz is always the same, being pure silica; feldspar and mica, however, as recently described, are of several kinds, being different combinations of silica and alumina, with several other substances. It results that there are many descriptions of granite, depending on the variations in the feldspar and mica, some almost utterly indestructible, others easily corroded by the atmosphere. Ordinary granite is a rock that is easily recognisable from the glassy-looking crystals of quartz, the opaque fleshy-looking oblong plates of feldspar, and the brilliant and metallic-looking spangles of mica, that may be seen variously disposed throughout it. It is used as a building-stone, and occasionally for statuary, especially colossal statues that are to remain in the open air.

Syenite is a rock, so named from its being formerly quarried at Syene in Egypt. It is often exactly like granite, except that instead of *mica* it has crystals of *hornblende*, the dark-green or black mineral before described. Many of the temples and colossal statues of Egypt were made of syenite, as may be seen in the British Museum. Syenite is also used largely for roadstone, as in London, where the macadamised roads are principally constructed of Guernsey syenite.

Elvan, or *quartziferous porphyry*, is a rock that is often very like granite, except that it contains neither *mica* nor *hornblende*, being made up of crystals of feldspar and quartz. It is used in some districts for stone walls and other rough purposes.

Felstone, or *petrosilex*, or *feldspathic trap*, is a rock that comes next to elvan, containing the same ingredients, but in a finer and more compact state, the crystals being rarely discernible, the whole often passing into a smooth fine-grained stone, without any distinct particles; the stone is used principally as a roadstone.

3. *Greenstone* is a crystalline rock composed of the two minerals, feldspar and hornblende. The varieties of greenstone are very great, because both its constituent minerals have many varieties, and these can be combined in many ways, and assume many different conditions, the crystals of each varying from large to small, or sometimes becoming so minute as to be no longer distinctly perceptible. Greenstone is often a durable rock, but sometimes very much the reverse, and its heaviness and dark colour are against its being used as a building-stone, except for rough purposes. When broken up and mixed with angular pieces of siliceous flint or quartz rock, it makes admirable roads, as it binds the purely siliceous particles together. When decomposed it makes excellent soil, from the quantity of potash, lime, and other alkalies which it contains.

Basalt is a rock that comes next to greenstone, from which it differs in being usually very fine-grained or compact, and containing some olivine and some magnetic iron. It often assumes a columnar structure, forming great ranges and wide-spread tabular masses of jointed columns, with cup-and-ball articulations, (fig. 15). This is the result of a tendency in basalt (which is often seen in other rocks) to form spheroidal or globular concretions, consisting of coats like those of an onion enclosing a central solid ball. As this tendency is developed throughout the whole mass as it cools, each ball increasing by acquiring fresh coats

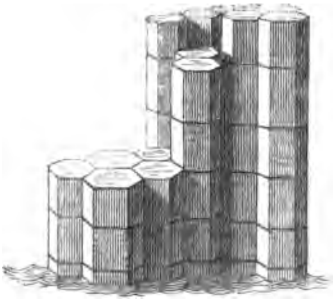


Fig. 15.

successively one over another, it results that the outside coats of adjacent balls at last touch each other, and are mutually squeezed on all sides, until no farther space is left for the enlargement of any of them. Now, if a pile of balls all of the same size, such as cannon balls, were arranged in regular rows, each ball will be touched by six others round it (fig. 16); and if they were all equally compressed, they would be squeezed into six-sided or hexagonal pillars. This combined with the "jointed" structure, common to all rocks, as the result of consolidation, and which in basalt gives a tendency to split into long prisms, produces "columnar basalt," such as is well-known in the "Giant's Causeway," "Staffa," &c.

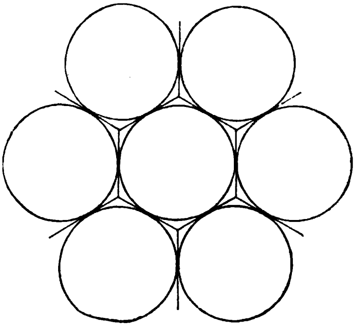


Fig. 16.

Basalt is often seen on the flanks of volcanoes, forming the deeper portion of lava streams, the upper part being a dark cindery stone, full of holes and pores like the "slag," or melted refuse from an iron furnace.

4. *Lava* is a term to designate such rough cindery stones as form part of a once-melted stream that has flowed from a volcano; sometimes lava looks mere cinders or "scoriæ," sometimes it is a black heavy compact stone, sometimes it assumes a glassy structure and passes into obsidian or volcanic glass, which is not unlike common bottle-glass, or the slag thrown from a glass-house. Another form of lava is pumice, which may be said to be the foam or froth of a lava stream, blown into a light cellular, porous structure by the escape of gases from the cooling mass below.

There are many more varieties of lava, such as trachyte, so named from its roughness, but there is no room here to enumerate them. We must not forget, however, a very characteristic volcanic rock, and that is what is called "tuff," or "peperino;" this consists of the ashes, and dust, and powder ejected from the craters of volcanoes, which, when they fall in the water, sink as mud, and become hardened into stone at the bottom; and when they fall on dry land, become equally hardened, either by the action of rain or by the pressure of their own weight, and that of subsequent accumulations.

5. The other principal division of rocks comprises those formed under water and therefore called—

Aqueous Rocks.—Aqueous rocks are, for the most part, formed either of lime, of silica, or of alumina. The rocks made of lime are called calcareous; those formed principally of silica are called quartzose or arenaceous, that is, sandy rocks; those in which alumina is abundant are called also argillaceous, or clayey rocks.

Limestone has been formed by the precipitation or tranquil deposition at the bottom of some water, of the mineral called carbonate of lime, which had previously been held in solution by the water. This may be seen very well in what are called "petrifying springs," where sticks, twigs, birds'-nests, or any other articles being placed in the water become encrusted by a coating of solid stone, which is carbonate of lime. In many caverns, water dripping from the roof deposits similar stony matter in pendant stems, like icicles, that increase by the successive application of fresh coats of carbonate of lime, till they form sometimes great pillars, sheets or irregular lumps of rock called stalactites, or sometimes spread in sheets over the floor, when they are called stalagmites. These productions add greatly to the beauty of many caverns.

That which we can see thus taking place in our springs, rivers, and caverns, namely, the formation of solid stone from water that had previously held it dissolved, in the same way that it dissolves salt or sugar, we may easily understand as taking place at the bottom of lakes and seas where it is concealed from our sight. Great sheets or layers of limestone are thus formed, enclosing the remains of animals or plants, or any other things that fall to the bottom of the water. These layers of limestone sometimes assume a crystalline form as they pass from the fluid to the solid state, and then become what we call *marble*. Almost all stones that admit of a polish and are designated as marbles are limestone, though some other stones are likewise sometimes called marble when polished. The varied markings in many marbles are often derived from shells, corals, and other fossils or organic remains that they contain, though sometimes they are derived from stains produced by different minerals. Hardly any rocks are more generally useful than the calcareous; all our best building stones, those that are at the same time the handsomest, the most easily worked, and the most durable, are limestone in some of its many varieties. Everyone is acquainted with the use of the soft limestone called chalk, with the stones called Bath stone, Portland stone, Caen stone, as well as with Derbyshire, Devonshire, and Kilkenny and other marbles. From the fine-grained crystalline limestone, the structure of which almost resembles loaf-sugar, all the finest statues of the world have been formed. That variety of limestone is, indeed, the only stone adapted to statuary purposes, and it is hence called statuary marble.

6. The *arenaceous* and *argillaceous* rocks differ from the *calcareous*, not only in their mineral composition, but in the method of their formation. The arenaceous and argillaceous rocks have not been held in solution in water; their particles result from the wear and tear of other rocks, and have merely been washed by the water, and transported from one place to another where they have been redeposited. This is very conspicuous in the rock called "puddingstone," or "conglomerate," which is evidently made up of fragments of other rock,

which have been rolled and washed about by the water till they have assumed the rounded form of pebbles, and have then been heaped together and bedded in sand, and recompacted into a solid rock.

Even the sand in which these pebbles are bedded is evidently the result of the same process carried out still farther. While the pebbles have been rounded, it is evident that the portions thus ground off their sharp corners would form sand, and it is equally evident that while, in some places, water would remove from pre-existing rocks pieces large enough to form pebbles, from others it would only succeed in removing small grains, which are what we call sand. This sand, when recompacted into a solid stone, becomes *sandstone* or *gritstone.* Of this rock there are almost endless varieties, according to the variation in the size, quality, and composition of the particles of which they are made up; many sandstones, for instance, contain calcareous and argillaceous particles, as well as arenaceous ones. Sandstones and gritstones are used almost solely for building purposes, some fine-grained kinds for fine work, and the coarser for rough walls. Millstones are generally formed of the purest and clearest, that is, the most siliceous grits.

Purely siliceous sand is used in the manufacture of glass, the sand being mingled with some alkaline mineral, such as soda or potash, and submitted to the heat of a furnace. Although the pure silica, when alone, would be quite unaffected by such heat, yet the alkali so acts on it as to melt and cause it to combine with itself, and is then said to act as a flux to the silica.

7. Of the *argillaceous rocks* the most decided and striking form is clay. This very fine-grained, smooth plastie material is familiar to everyone. It consists of the waste or refuse of other rocks, ground down to the last degree of fineness, so that the little particles, instead of being visible as they are in sand, are too small to be perceptible to the naked eye. This minute subdivision of particles, however, is not of itself suffi-

cient to make the material clay, because if they were purely siliceous they would remain fine sand. It is necessary also that there should be a considerable quantity of aluminous matter mingled with the siliceous for the resulting substances to be argillaceous.

When this mixture of alumina with the silica is in sufficient proportion, and there is no mixture with lime, the clay is in the best state for making bricks. Still finer varieties of clay, with carefully-assorted admixtures of silica and other mineral substances, are necessary for the manufacture of pottery and porcelain. When clay contains a certain portion of lime mixed with it, it is called "marl," a substance that is highly useful in agriculture. Clay mingled with sand is called "loam;" and when naturally hardened and consolidated, is known by various names, such as "clunch," "clod," "binds," "metal," &c., terms chiefly used by colliers. Indurated clay that splits into thin plates or lamina is called "shale."

8. Clay slate, a substance we are all familiar with in the roofs of our houses, and the slates used in schools, is another and very peculiar form of indurated clay, which is worth describing a little more in detail. All "slate" was once very fine mud deposited at the bottom of some water. It was afterwards hardened and compacted together into solid stone, and then was affected by some wide-spread and mysterious agency, that gave the whole a tendency to split indefinitely in one given direction. Great ranges of mountains, the beds of which are tilted up and twisted about in many directions, have been affected by this agency, in such a manner that all the finer-grained portions will only split in one direction, according to the compass, say, for instance, along lines running N.E. and S.W.; the same structure being perceptible however deeply we may quarry into the mountain.

Fig. 17 will aid in the understanding of this structure of cleavage: the finer lines, A B, represent the directions of the cleavage plane, or that in which the rock naturally splits, and C D the lines of the bedding or stratification. This mention of rock masses having been made to assume a different structure from what

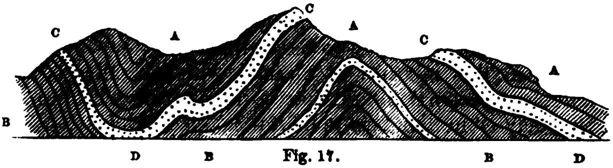


Fig. 17.

they originally had, by the action of natural forces on a large scale, leads us directly to the altered, or

9. **Metamorphic Rocks.**—The metamorphic or altered rocks, are those principally which have been affected by heat. Aqueous rocks, such as ordinary clays, sands, shales, or sandstones, when great masses of igneous rock have come in contact with them, or when great heat has passed into them in any other way, have lost much of their original character, and have assumed more or less of those of igneous rock. Gneiss is one of these rocks, which consists, like granite, of crystalline particles of quartz, feldspar, and mica; but instead of being confusedly interlaced, they are arranged in thin layers or plates called foliæ. Mica schist is a similar fissile rock, in which the mica greatly predominates over the other materials. There are also others, named in like manner from their principal constituent, such as chlorite schist, hornblende schist, and so on.

These metamorphic rocks, with the exception of clay slate, have no particular uses; they are employed for rough building purposes in countries where they abound. Clay slate, however, from the clearness and fineness of its grain, and from the beautiful smoothness and levelness of the surfaces of the thin plates or slabs into which it naturally splits, is capable of being put to a variety of useful purposes, beyond those already alluded to. It is daily coming into more general use for tables, baths, steps, shelves, and other similar domestic conveniences.—J. Beete Jukes.

Vegetable Physiology.

BY EDWIN LANKESTER.

LESSON I.

WHAT PLANTS ARE MADE OF.

> **" And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit-trees yielding fruit after his kind whose seed is in itself upon the earth : and it was so."**

1. Although, at first sight, there might appear nothing easier than to distinguish plants from stones and animals, it is really a very difficult matter. For since the application of the microscope to the observation of minute objects, it has been found that there are many of them in which the characters of mineral, plant, and animal are so combined, as to present the greatest difficulty in assigning them to one kingdom or another. There is a family of beings called brittle-worts, the entire substance of which appears to be composed of flint. They assume very definite crystalline forms, square, round, triangular, and oval, as may be seen in fig. 1, and are marked in the most singular and beautiful manner.

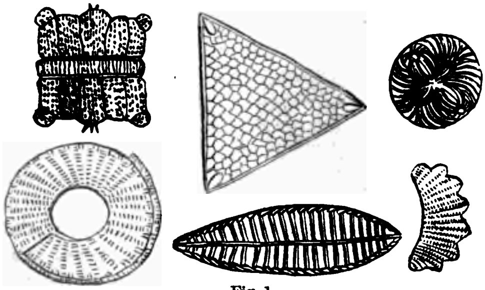


Fig. 1.

These forms, which on a cursory glance might be taken for crystals, however, move and are endowed with motion like animals. But we know now that plants have a power of movement; and as these brittle-worts resemble, in other respects, plants composed of but one cell, they are now regarded as true plants.

2. Difficult as it is to distinguish many of the minute powers of organized beings, there are certain great functions performed by plants in creation, by which they are easily recognised, and the study of which, and of the structure of the organs by which they are performed, constitutes a distinct branch of knowledge called Botany. One of the most prominent of these functions is that they feed on mineral or inorganic matters. Man and the animal kingdom, *generally*, live either on the bodies of other animals or on substances procured from plants, but plants take up into the cells of which they are composed inorganic or mineral compounds.

3. Another prominent function of the vegetable kingdom is, that they are constantly giving out oxygen gas. This substance, which is one of the gases found in the air we breathe, is constantly being withdrawn from the atmosphere by animals, and the plant is always engaged in supplying that which the animal consumes. All plants perform these functions, whether they consist of single cells, as in the Red Snow plant (fig. 2), or of roots, stems, leaves, and gay flowers, as in the plants of our gardens, or the trees of our forests (fig. 3).

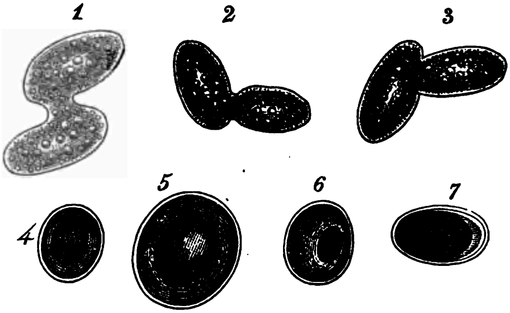


Fig. 2.

4. In order to study the vegetable kingdom successfully, it will be found of great service to examine the nature of the *materials of which it is composed.* Nor is this so difficult as might be imagined; for although plants present to us a vast variety of forms, and their products are of the utmost importance, they are yet composed of a few simple elements. By a knowledge of the nature of these elements, and more especially their chemical relations, great light has been thrown on the nature of the functions performed by plants.

Fig. 3.

5. The ultimate particles which form the bodies of animals are first taken from " the dust of the ground " by plants; and the varied productions of the vegetable kingdom, such as sugar, citric acid, indigo, gums, resins, India rubber, and the substances used in medicine, are all definite chemical compounds of a few elements whose properties can be studied quite independently of their existence in the cells of plants. It is not our purpose here to enter into any details of the chemistry of the elementary matters of which plants are compounded, but to draw attention to those physical and chemical qualities which render them especially qualified to fulfil the functions they perform in the vegetable kingdom.

6. Of the sixty-five elements enumerated by chemists only about eighteen enter into the composition of plants. They are as follow:—

Organic :—1. Carbon. 2. Hydrogen. 3. Oxygen. 4. Nitrogen.

Pseud-organic :—5. Sulphur. 6. Phosphorus.

Inorganic :—7. Chlorine. 8. Iodine. 9. Bromine. 10. Silicon. 11. Potassium. 12. Sodium. 13. Calcium. 14. Magnesium. 15. Alumina. 16. Iron. 17. Manganese. 18. Copper.

In the above enumeration these are divided into *organic* and *inorganic*, in order to indicate a much wider and more extended existence of the one group than of the other. Carbon, hydrogen, oxygen, and nitrogen, are called *organic*, because they are found universally present in organised beings—beings having organs. Parts of plants and animals exist without any trace of these elements; but no entire organic being, even a one-celled plant or animal, is found deficient in all of them. Sulphur and phosphorus are included in a separate group called pseud-organic, because although not determined to be essential to organic life, they are very generally present in the compounds which are. The term *inorganic* is not a happy one. It is intended to imply that the elements so called, although entering into certain plants, are not *universally* necessary; they are often as essential to life, as the organic elements themselves.

7. Of the four organic elements, the only one that is solid is *carbon*. This substance enters so largely into the composition of plants, that, when burned slowly, the other elements are driven off, and the carbon is left in the form of what we call charcoal. Carbon is not often found pure in nature. It occurs, however, in the form of the diamond, the most precious of gems, and of graphite or black lead, the substance which is used for making pencils. It is not in its pure form that it is taken up by plants. When combined with oxygen, it forms a gas called carbonic acid gas, which is very abundant in nature. This gas is given out from the lungs of animals when they breathe, and is also formed wherever combustion is going on. Thus large quantities

are being thrown into the atmosphere by man in the use of heat for his cooking, travelling, and manufacturing purposes. Immense quantities are also being given into the atmosphere from the bowels of the earth by mineral openings and volcanoes.

8. Carbon possesses remarkable physical and chemical properties, and it is to these that the life of plants and animals owes many of its distinguishing features. It is solid at the ordinary temperature of our atmosphere. It readily burns when it comes in contact with the oxygen of the air. It is on this account that it is used for heating and lighting purposes by man.

9. *Hydrogen*, as one of the elements entering into the composition of *water*, is found most abundantly distributed in the vegetable kingdom.

10. Water is the great basis of all organised bodies. Without it no plant or animal can exist. Whatever other elements are introduced into a vegetable or animal body, they must pass into their system by the agency of water. Some water plants are almost entirely composed of water. *Ceratophyllum demersum* (fig. 4), a plant of this kind found in our ditches and ponds, has been found to contain, in every one hundred pounds, ninety pounds of water. Other aquatic plants contain probably quite as much. Succulent plants also contain a large proportion of water, and even the timber of which solid trees are composed loses a quantity of water by drying. Hydrogen is also a conspicuous element in the substances called oils, both fixed and volatile, also in resins, and in the curious and

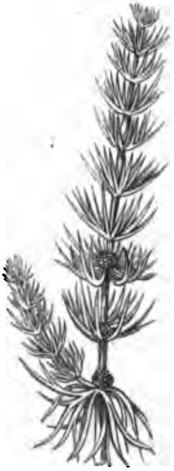


Fig. 4.

highly important compounds now so much used in the arts, called caoutchouc and gutta pertsha.

11. By withdrawing the oxygen from water, hydrogen is easily procured. In this way it is undoubtedly introduced into the system of plants in those cases where it exists without oxygen; there are, however, other sources of hydrogen. With nitrogen, hydrogen forms ammonia, which is a very important ingredient in the food of plants.

LESSON II.

WHAT PLANTS ARE MADE OF—*continued.*

> **" He causeth the grass to grow for the cattle, and herb for the service of man: that he may bring forth food out of the earth."**

1. Of the four organic elements *oxygen* is the most chemically active. It is constantly entering plants in the form of carbonic acid and water, and they have the power of separating it from these compounds, and returning it to the atmosphere. This process may be easily seen by exposing a few leaves of a water plant in a tumbler of water to the rays of the sun, when bubbles will be seen to rise, which are pure oxygen gas. Oxygen is very abundant in nature. As a gas it exists pure in the air, forming twenty-one out of every hundred parts of the atmosphere. It is invisible, but its chemical agency is manifested in all kinds of combustion which take place in virtue of the oxygen in the atmosphere.

2. Nitrogen is the least active of the organic elements. Like hydrogen and oxygen it is a gas, and like oxygen it enters into the composition of the atmosphere. Seventy-nine parts out of every hundred of atmospheric air are nitrogen. In this fact we have revealed its true nature. It tempers the activity of the oxygen of the air. It is chemically inactive; although

existing in large quantities in the atmosphere, it exerts no active influence on the substances with which it comes in contact. It nevertheless plays an important part in combination. The most generally diffused of vegetable substances possess it, and it is the ingredient which characterises the compounds which, produced in plants, afterwards become the flesh of animals. Nitrogen is not introduced into plants in its pure form: with hydrogen it forms the gas ammonia. It is through the ammonia they absorb that plants obtain nitrogen.

3. The pseud-organic elements, *sulphur* and *phosphorus*, resemble each other in some of their properties. The most interesting feature in the relation of these elements to plants is their constant presence in those compounds, which, containing the four organic elements, are found essential to the life of organized beings. These compounds are known by the names of fibrine, albumen, caseine, &c.

Sulphur is also found in some special vegetable compounds, as in the volatile oils of mustard, horseradish, and other oils belonging to the natural order *Cruciferæ.* This accounts for the smell of sulphuretted hydrogen which is emitted from these plants during decomposition or boiling. Sulphur, combined with oxygen, is called sulphuric acid, or oil of vitriol. This acid, combined with lime and other earths and alkalies, forms the salts called sulphates, which are frequently taken up by plants.

4. Phosphorus with oxygen forms phosphoric acid. This acid, like sulphuric acid, combines with earths and alkalies. In the animal kingdom, combined with lime, it constitutes the principal portion of the earthy matter of which the bones are composed. It can be obtained by animals only from plants, hence, for some plants, it is an essential ingredient. The plants from which man obtains phosphate of lime are those which are most cultivated, and it is found they will only thrive when the soil in which they grow is supplied with a certain quantity of phosphates. Guano,

and the artificial manures, now so extensively employed, derive most of their value as manures from the phosphorus they contain. It is thus that the phosphorus which served for the skeletons of the gigantic reptiles and fishes of past ages, is now hewn out of the solid rock, in order to supply the increasing demand made by man for this material in the crops which he cultivates as food for himself and for the animals he consumes as food.

5. The elements we have as yet spoken of all belong to the class called non-metallic. They are none of them metals, although some of them are capable of uniting with the metals. We have now to speak of the *inorganic* elements. Some of these also are non-metallic, and of these we shall speak first.

6. Of the substances contained in the list of the inorganic elements of plants, *chlorine* is perhaps the most important. Chlorine is a gas of a green colour, and a powerfully suffocating odour. It is not found anywhere pure in nature. Like oxygen, it is a supporter of combustion, and it is found in combination with many of the metals. The most abundant compound of this kind in which it is found is common salt or sea-salt. Common salt is composed of the gas chlorine and the metal sodium. The fact of the presence of chlorine in sea-salt at once indicates its importance in relation to the vegetable kingdom. The great distinction between the waters of the ocean and fresh water is the presence of salt. The seas of the earth teem with vegetable inhabitants. Thousands of species of sea-weeds exist, and their varied forms depend upon chloride of sodium. Thousands more species of plants grow on the shores of the ocean, and will not live where they are deprived of the influence of this substance. It is thus that we learn the importance of the inorganic elements in determining the existence of plants; and not of plants only—the animal inhabitants of the sea *subsist* on the plants that find nutrition there, and thus we find a large proportion

of all the organized beings in creation dependent upon the two elements chlorine and sodium.

7. Although not absolutely necessary to the existence of inland plants and injurious to them in large quantities, it appears to be not improbable that salt enters into the composition of all plants. Most animals require small quantities of it. It is the only mineral man eats. Away from the sea there appears to be no other natural source of salt but plants; and it is therefore probable that all plants obtain small quantities from the soil in which they grow, which soil, in most instances, has been derived from rocks deposited from sea-water.

8. Of the inorganic elements, *iodine* next claims our attention. We are almost entirely indebted for this substance to vegetable chemistry. Iodine, like chlorine, exists in sea-water in combination with sodium. Sea-weeds take up the iodide of sodium, and from their ashes iodine can be procured in the same way as chlorine. Though much more sparingly distributed than any of the elements we have yet spoken of, it is nevertheless very generally diffused.

9. *Bromine* resembles iodine. It has the same chemical properties: it exists under the same circumstances, and is obtained in the same way. It is less abundant than iodine, and although undoubtedly a constituent of plants, too little is known of its relations to the vegetable kingdom to need any further notice.

10. Another non-metallic element is *silicon.* Little is known of the nature of pure silicon, and its greatest interest, in relation to the life of plants, is, that in the form of silex, silica, or flint, it enters largely into the composition of vegetable bodies. When a stack of hay, or wheat, or barley is burnt down, there is often found a quantity of glass amongst the ashes. This glass results from the union of the silica and potash of the plant. All glass is formed by the union of silica with an alkali. Silica occurs more abundantly in some

plants than others: thus it is found very generally in the stems of palms and grasses (figs. 5 and 6). It is said to exist so largely in the stems of some palms, that the woodman, in cutting them, has his axe frequently broken. Sometimes silica collects in the stems of palms, and it is procured for commercial purposes, and sold under the name of *tabasheer*. It is more commonly found in endogenous plants than in exogenous plants: amongst the latter class of plants, however, there is a curious instance of its occurrence in large quantities, and this is in the *scabious Deutzia*. In this plant it is thrown off from the

Fig. 5.

Fig. 6.

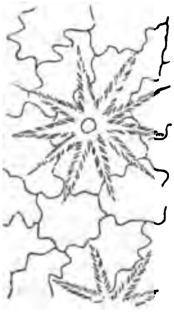


Fig. 7.

cuticle in the form of stellate bodies (fig. 7).

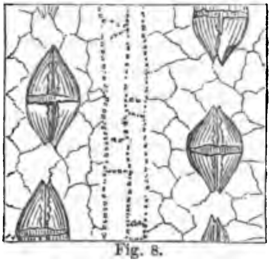


Fig. 8.

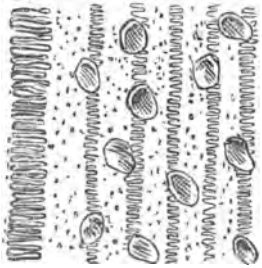


Fig. 9.

11. Amongst the lower plants silica is very common in some families. This is the case with the horse-tail family. One species of horsetail, called in the markets Dutch rush (fig. 8), is used by cabinet-makers, on account of its roughness, for some kinds of polishing. In this case, as well as others, the silica has been so thoroughly worked, as it were, into the tissues, that on removing the organic matter the silica presents a perfect cast of it. The organic matter may be removed by submitting the plant to the action of nitric acid or heat. Portions of the husk of rice, wheat, oat, and other grasses, when submitted to this treatment, readily indicate the existence of the silica (figs. 9 and 10). The object of the silica in these cases seems to be the affording the greatest amount of strength with the least amount of material.

12. The plants in which silica most abounds are the brittle-worts, which have been before alluded to (fig. 1). The silica in these minute beings gives to them a singular and interesting character. As silica is one of the most indestructible of substances, it has given to these organisms an ever-enduring character. Once formed they seem never to be destroyed.

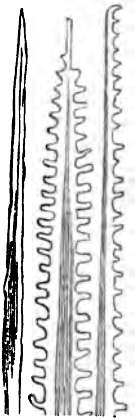


Fig. 10.

Though swallowed by myriads by every creature that inhabits the water, they pass through all processes of digestion untouched. The guano, which is the excrement of birds, presents numerous forms of them which had been previously swallowed by fishes, and probably by other creatures before them, and yet perfectly retain their forms. They are deposited in immense quantities at the bottom of rivers, lakes, and seas. They present themselves in every formation, from the Silurian rocks to the mud of the wayside puddle that was formed only a week ago. They penetrate into the bowels of volcanoes by the agency of water, and they are belched forth again with the molten lava, but it has not destroyed them. Thin sections of lava-stones reveal them by thousands when placed under the microscope. Of all organic beings that have played a part upon the surface of our planet, they are probably the only ones that have left behind them a complete record of their forms and existence.

13. A curious question arises here. How does this insoluble indestructible matter get into the delicate tissues of plants? Here chemistry, as in so many other instances of the phenomena of life, solves the question for us. Silica, though insoluble alone, forms readily-soluble compounds, with the alkalies potass and soda. It is thus that this compound, harder than steel, and enduring as the diamond itself, is held in solution in the waters of the ocean, and dissolved from the soil by every shower that falls on the earth.

LESSON III.

WHAT PLANTS ARE MADE OF—*continued.*

"Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree in the which is the fruit of a tree yielding seed; to you it shall be for meat."

1. The metallic elements of plants must now engage our attention. There are seven of these. Two constitute,

with oxygen, the alkalies, potass and soda; three form, with the same element, the earths, lime, magnesia, and alumina. The other two are common metals, iron and manganese. Of these the most important are the alkalies. ***Potassa***, the oxide of potassium, is a very general constituent of both plants and animals: it does not, however, exist in a pure state, but in combination with sulphuric, phosphoric, or some other of the acids formed by organic processes. The presence of the inorganic matters of plants is usually ascertained by an examination of the ashes left in burning a plant. If a plant, or a portion of one, is put into a retort and heated, the first thing given out is water; then comes carbonic acid gas; after this ammonia, sulphuretted hydrogen, &c. Thus all the organic and gaseous elements are volatized; but when the heat has been raised to the highest point, there is always left a quantity of indestructible ashes. These ashes contain the inorganic elements. It is in them we find potassa.

2. Potash in some one or other of its combinations appears essential to plants growing away from the sea-shore. Rob the soil of this constituent and they perish, apply it and they flourish. As yet no chemical process has been discovered by which potash can be separated more economically from the soil than by plants. Hence the ashes of plants are imported in immense quantities into this country every year from America and Russia, in order to supply the demand for potash.

3. Sodium has already been seen to play an important part in the vegetable kingdom when combined with chlorine. What potassium is to land plants, sodium appears to be to sea and shore plants. Although perhaps both metals are necessary to all, certain plants demand much more of one than others. Thus shore plants which grow inland take up more sodium than ordinary land plants, whilst plants growing near the sea extract more potash from the soil than shore plants. As potash is obtained from land plants, so soda is obtained from sea and sea-shore plants. The *Salsola kali*

(fig. 11) is cultivated on the borders of the Mediterranean, and the ashes are sold under the name of *barilla*. Sea-weeds of various kinds, but more especially the Bladder wrack (fig. 12), are burned on the shores of Scotland and Ireland for the sake of the soda they yield. The ashes of sea-weeds are called *kelp*. Both soda and potash when obtained in this way present themselves in the form of a carbonate.

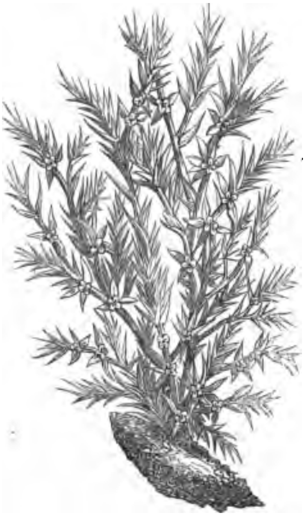


Fig 11.

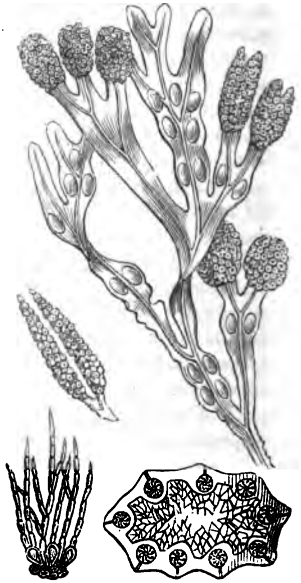


Fig. 12.

4. *Calcium* is the metallic basis of the earth called lime. Neither calcium nor lime are found pure in plants. Calcium always occurs in the form of a salt of lime. Carbonate of lime is the most common form in which lime is found in the external world, and it is through its medium that plants are supplied with lime. Although

Fig. 13.

carbonate of lime in the form of chalk, limestone, and marble, is insoluble, and could not thus enter into plants, it is easily soluble in water containing carbonic acid. As before mentioned, carbonic acid is very abundant in water, so that the conditions for the solution of carbonate of lime exist in most waters. It is thus that lime is very freely conveyed into plants, and becomes a constituent of their tissues. Some plants especially thrive when there is lime in the soil, and these are called calcareous, or chalk plants. It is probable that those animals, such as the shell-fish which have so large a quantity of carbonate of lime in their composition, obtain it from the plants on which they feed. Certain forms of snails occur in prodigious quantities in the chalk districts of England, where they obtain the carbonate of lime necessary for their shells from the plants on which they feed (fig. 13).

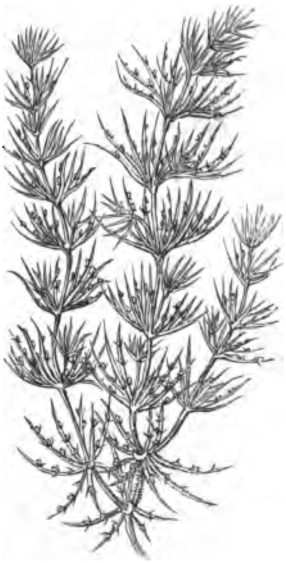


Fig. 14.

5. The insoluble nature of the salts of lime causes them to assume the form of crystals in the plant. In the common *Chara* (fig. 14), carbonate of lime is found crystallized upon the surface of the plant and in the interior of its cells (fig. 15). Oxalic acid is found in many plants, and combining with lime pro-

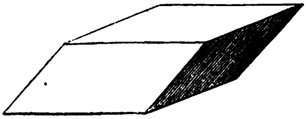


Fig. 15.

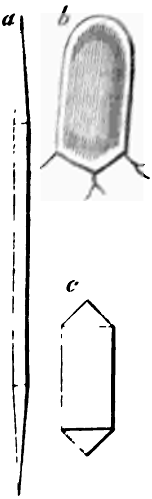


Fig. 16.

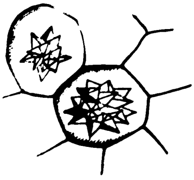


Fig. 17.

duces crystals of various forms. Those first observed were of a needle form, and called *raphides* (fig. 16 *a*). Sometimes several are found together, constituting what were once called crystal glands (fig. 17). These crystals are found especially in plants belonging to the Cactus and the Rhubarb tribe (fig. 18). Eighty parts of every hundred of dried specimens of a species of Cactus were found to be oxalate of lime. The root of the common rhubarb contains so large a quantity of these crystals as to render it gritty to the taste. They have also been found in the common dandelion (fig. 19). Sulphate of lime is easily crystallized out of its solutions, and it is occasionally found in plants. It crystallizes in the form of single or double octohedrons, in a thin form like the crystals of gypsum from Montmartre (fig. 20).

6. The other two earths may be spoken of together, as too little is known about them to enable us to say anything more than that they are very frequently found in the composition of plants. Magnesia is found in the strata of the earth in considerable quantities, and one formation, the magnesian limestone, is characterised by its presence. It is also found in some mineral springs as those of Epsom. It is probable that it enters into the composition of plants as a substitute for potash or soda where those salts are deficient in the soil.

g. 18.

7. *Alumina* constitutes the basis of all those kinds of earth which we call clay, and is an essential element of mud. Many plants will not grow except in a clay soil, and others flourish only in mud. This may arise from the physical properties of alumina; but as this substance is found in the ashes of many plants, it must be regarded as one of the things of which they are made. A good instance of a plant preferring a clay soil is the Coltsfoot (fig. 21). In the spring it puts forth its yellow flowers on single flowerstalks; these disappear, and then the leaves come up, often in such numbers as to cover a piece of barren clay soil which will support no other form of vegetation.

Fig. 19.

8. The presence of *iron* in plants has been made out in a large number of instances. Iron does not, however, any more than the other metals, enter into their tissues pure. Although in very small quantities, it seems a general constituent of plants, especially of those which are used as food. In this we see the provision that is

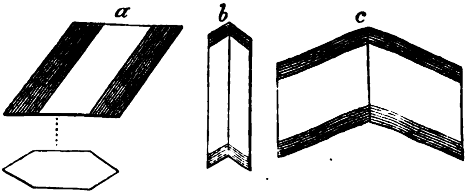


Fig. 20.

made for supplying man with a very important element of his body. The blood and muscles of all animals contain iron, and when sufficient quantities of this substance are not present disease ensues.

Fig. 21.

In iron springs—chalybeate waters—there are constantly found various forms of algæ, which seem to depend for their existence on iron. It has been lately discovered that the little brittleworts contain in the silica of which they are so largely composed a certain quantity of iron, and this probably accounts for the brownish or yellow tinges which these minute organisms present.

9. *Manganese* is one of the metals which is very constantly associated with iron in plants, and claims to be noticed as one of the elements entering into their composition. These are all the substances referred to in the list of inorganic elements. Other metals have been found in plants; and it is very probable that just as potassium and sodium supplement each other, or take each other's places, so other metals may supplement iron. It is thus that we may account for the fact of copper, arsenic, and some other metals, being recorded as constituents of plants.

LESSON IV.

COMPONENTS OF PLANTS.

> "The rain cometh down, and the snow from heaven, and returneth not thither, but watereth the earth and makest it bring forth and bud, that it may give seed to the sower, and bread to the eater."

1. In the account above given of the inorganic elements, the principal compounds they form in plants have been described. The compounds of the organic elements are far more important, and demand a separate notice. They may be divided into two great classes, the *assimilable* and the *non-assimilable.* By assimilable is meant those substances which form part and parcel of the vegetable fabric, and which are found more or less in every plant and vegetable tissue. They are the substances which are employed in the nutrition of the plant. On the other hand, the non-assimilable substances are those which are only found in special plants, and which, after having once been formed, are insusceptible of further change on becoming changed into the assimilable or nutritive compounds of plants.

2. The following table will give an idea of the nature of these compounds:—

A. *Assimilable.*—1. Ternary compounds, consisting of three elements, *viz.*, carbon, hydrogen, and oxygen: *a.* Cellulose, *b.* Starch, *c.* Dextrine, *d.* Sugar, *e.* Oil.

2. Quaternary compounds, consisting of four elements, *viz.*, carbon, hydrogen, oxygen, and nitrogen: Protein, Albumen, Fibrine, Caseine.

B. *Non-assimilable.*—1. Colouring matters. 2. Acids. 3. Alkaloids. 4. Volatile oils. 5. Resins. 6. Hydrocarbons.

Varied as are the products and the nature of the compounds found in plants, they may be all referred to one or other of the foregoing heads.

3. The substance which stands first amongst the assimilable compounds is *Cellulose.* This name was given by the French chemists to certain portions of the cover-

ings of the cells of plants, but has now been adopted generally to express the walls of the cells of which all plants are composed. A vegetable cell is always composed of two parts: first, an internal substance, which is first formed and assumes the form of a round spot, or a layer or deposit, on the inside of the cell; second, an external membrane or cell-wall. It is this external membrane which is composed of cellulose. *Lignine* and *Sclerogen* are terms applied to the cell-wall when it is very hard, and these substances are said in some respects to differ from each other and from cellulose. It is convenient, however, to use the term cellulose to express the material of the cell-wall wherever formed.

4. Cellulose possesses remarkable physical and chemical properties, on which the life of plants may be said to depend. In the first place, it is insoluble in water; and this property will be seen to be essential when it is recollected that plants are only nourished through the aid of water, which must pass through the walls of the cells in order to perform its functions in the system. In the next place, cellulose is converted into starch by the addition of strong sulphuric acid (oil of vitriol). This is a fact of great importance in vegetable physiology, as by it we can detect the presence of cellulose in parts which are only made visible by the microscope. This is done by the addition of iodine to the part under examination: this has the power of giving a blue colour to starch, but not to other substances. Cellulose is composed of carbon, hydrogen, and oxygen.

5. Cellulose, with the exception of protein, is the most universally diffused of vegetable substances. It is found alike in the delicate cells that constitute the hair, and the solid fibres that form the timber of which the trunks of gigantic forest trees are composed. From this it will be seen that it enters into the food of animals, is of the utmost importance in furnishing the material which man employs in the form of wood, and in the various vegetable textile fabrics. Nor does its use ter-

minate here, for from this material all forms of paper are manufactured, from the hard papier-maché to the most delicate kinds of writing and printing papers. It is also the cellulose of cotton or hair which undergoes change in the formation of gun-cotton; and this substance is again soluble, forming collodion, which is very useful in the arts, and has lately been most extensively employed in photography.

6. The next substance in importance in the structure of plants is *Starch*. Substances which do not enter into the composition of the cell-wall are found in the interior of the cell, and are called cell-contents. Among them the most frequent is starch. If we take any part of a growing plant, a portion of a root, or the tuber of the potato, and place it under the microscope, we shall find the cells of which it is composed contain minute granules of various forms and sizes. If to these we add a little iodine, they become immediately coloured blue. These are starch granules. The substances called in the arts starch, arrowroot, tapioca, and sago, are examples of tolerably pure starch, obtained from various plants.

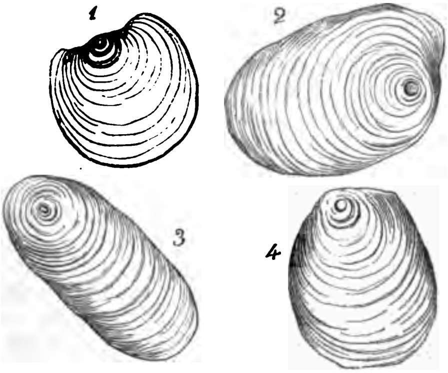


Fig. 22.

7. Starch has nearly the same chemical composition

as cellulose, but very different physical properties. Starch is insoluble in water, but its granules are easily diffused through it. The way in which starch is prepared for commercial purposes is by bruising the tissues of plants, and then placing them in water. The cellulose sinks to the bottom, but the starch is diffused in the water, which being poured off the starch settles from it in the course of a few hours. Starch is a most important article in the diet of human beings and animals, and is employed in the arts for the stiffening of linen and cotton goods.

8. When starch granules of arrowroot are placed under the microscope, they present the appearance of having a little central spot lying on the top of a series of little plates (fig. 22). These plates, although they appear to be flat, are not so, for if a drop of sulphuric acid be placed upon them, or they are submitted to heat, they will swell up, showing that they are compressed vesicular bags (fig. 23). When cut through they present other little bags in their interior (fig. 24). Starch is only formed in cells as long as the layer of protein, called protoplasm, is present, and it is from this substance that it is originally developed, layer upon layer being deposited as long as the protoplasm remains (fig. 25).

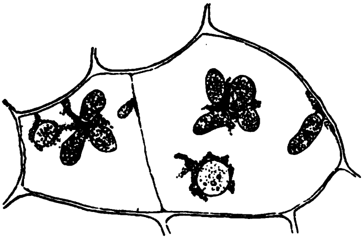


Fig. 23.

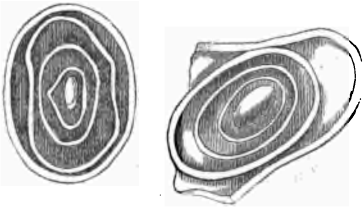


Fig. 24.

9. The forms assumed by the granules of starch are

very numerous, and dependent upon the size and form of the cell, the number of granules developed, and a variety of other causes. The forms of starch are very characteristic of different plants. Frequently several granules adhere together, forming a compound granule, and this kind assumes a variety of forms. It is seen in starch from the root of the common Cuckoo-pint (fig. 26). In some instances they are hollow, a point which can clearly be made out under the microscope (fig. 27). This can be seen in starch from the corms of the Meadow Saffron.

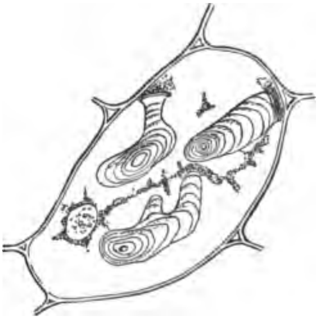


Fig. 25.

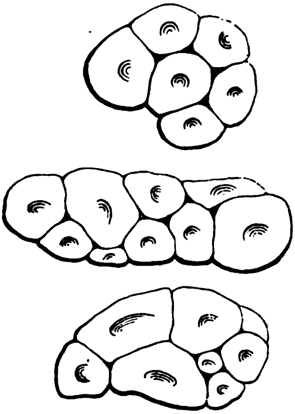


Fig. 26.

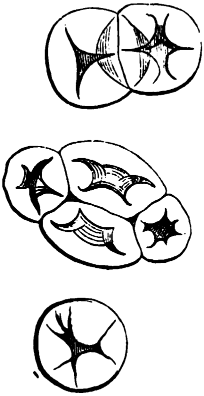


Fig. 27.

10. Starch, though not soluble in water, is easily

converted by the chemistry of the plant into substances which are; one of these is *dextrine*. This substance closely resembles gum, and is regarded by some botanists as analogous with it. It is readily soluble in water, and can be made artificially by heating starch-paste up to a temperature of 120°. The difference between gum and dextrine seems to be, that gum is not convertible into sugar whilst dextrine is. Dextrine has the same composition as starch and sugar, and is a transition from the former to the latter. This evidently goes on in some vegetable processes. Take, for instance, germination, which is promoted for a special purpose in the process of malting. Barley seeds are taken when ripe and placed in circumstances to make them sprout. In the beginning of this process

Fig. 28.

they contain starch, and at the end of it, when they are converted into malt, they contain sugar. The object of the malting has been to obtain the sugar for brewing beer; but in the intermediate stage of the process dextrine was present, and it is from germinating barley that it is obtained for commercial purposes.

11. *Gum* is evidently dextrine, rendered by some chemical cause unsusceptible of passing into sugar. It is found in considerable quantities in the tissues of some plants; and from others, as the various species of Acacia, it is exuded so plentifully as to be collected for use (fig. 28). It is called gum-acacia, gum-arabic, and gum-senegal. But whatever called or from whatever source procured it has the same composition. Although used in medicine, it is an inert substance, and has no nutritive properties as an article of diet.

12. *Sugar* is a very common constituent of plants. Although obtained as an article of diet from the sugar-cane (fig. 29), it exists in large quantities in other plants, if it be not a universal constituent of them. Chemists recognise two kinds of sugar, cane-sugar and grape-sugar. They both contain carbon, hydrogen, and oxygen, but differ in the quantities of hydrogen and oxygen they contain. It is also found that cane-sugar will not ferment till it is converted into grape-sugar. Sugar is soluble in water; but its great chemical characteristic is the readiness with which it is decomposed and converted into alcohol. This process

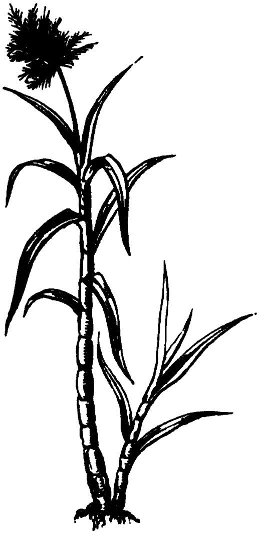


Fig. 29.

consists in the loss of a certain quantity of carbon and oxygen in the form of carbonic acid gas, and is called fermentation. It is by means of this process that the juice of the grape, the liquor of malt, and other saccharine solutions, are converted into wines, beer, and spirits.

13. Sugar is not a constant constituent of the vegetable kingdom, but is found at certain seasons in plants. It is found, for instance, in many plants under the following circumstances:—1. During germination, as in the case of the barley in malting. 2. At the time of budding. In the spring of the year many plants yield sugar in their sap. The common birch yields it in this country, and the sap is employed on that account to make birch wine. In America large quantities of maple sugar are consumed, which is procured from the sap of the sugar maple. 3. Just previous to the opening of the flowers many plants contain large quantities of sugar in their stems. This is especially the case with the grasses and palms. The sugar-cane, which is a grass, is cut down at this season. It is at this time that the grasses of our meadows contain their largest proportion of sugar. Sugar is contained at this season in barley, oats, rye, rice, wheat, and maize. In America, the maize is used for obtaining sugar. 4. The flowers often contain sugar. It is frequently exuded from the surface of the petals; and it is from this source that many insects obtain the sugar they consume as food, and the bee obtains it for the purpose of storing it as honey for the young brood. 5. The juicy fruits of most plants contain sugar. These are familiar enough, as, where they are free from any poisonous admixture, they

Fig. 30.

are used by man as an article of diet. With but few exceptions all fruits cultivated in our gardens and orchards contain sugar. 6. The roots of plants frequently contain sugar. Carrots, turnips, and parsnips are familiar examples. On the Continent, the beetroot is cultivated most extensively on account of the sugar which is contained in it, which is extracted, and furnishes a very large proportion of the sugar used by the people of France and Germany.

Various modifications of the above substances have been pointed out by the chemist, as lichen-starch, inulin, amyloid, mannite, liquorice, and eucalyptus sugar. They all, however, possess the same composition, and more or less of the properties which have been pointed out as characterising cellulose, starch, dextrine, and sugar.

LESSON V.

COMPONENTS OF PLANTS—*continued.*

"Consider the lilies of the field, how they grow; they toil not neither do they spin: And yet I say unto you, That even Solomon in all his glory was not arrayed like one of these."

1. Amongst the substances having three elements in their composition are included the fixed oils. They are not exclusively vegetable products, as we now know they may be formed in the animal body from starch. It is probable, that in plants they are formed by the withdrawal of oxygen from starch. The following table indicates the chemical difference between this group of substances and the others:—

	Starch.	Grape Sugar.	Oil.
Carbon . . .	12	112	11
Hydrogen . .	8	12	10
Oxygen . . .	8	12	1

Oil, whether it goes under the name of tallow, fat, lard, suet, or butter, has the same general composition and physical properties.

2. Oil is a substance of the utmost importance to man. The vast mass of machinery which he employs in every art and occupation is only kept from fire and destruction by its agency in diminishing friction. Yet man is not supplied with oil from so many sources in the vegetable kingdom, as its general presence might lead us to expect. It is obtained principally from the seeds of plants, of which the various kinds of palms, the rape, the poppy, the hemp, the flax, and the almond, may be taken as examples. In the olive (fig. 31), it is not obtained from the seed but from the fruit, in which the seeds are included. When the tissues of plants are placed under the microscope, oil is found to be a very general ingredient in their contents.

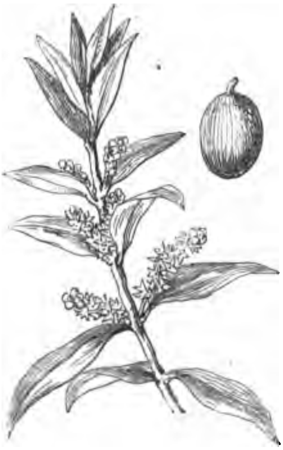


Fig. 31.

3. Wax is a substance which, in its chemical and physical properties, resembles the fixed oils. It is very frequently present in plants, and is more especially found upon their surface. That which is called the "bloom" on fruits is wax. It forms a layer of varying thickness on the leaves and stem of many plants. It is found in large quantities on the wax-palm (fig. 32). Sometimes it forms a part of the milky juices of plants. It is found in the juice of the cow-tree of the Caraccas.

4. The second group of assimilable substances are distinguished by possessing the four organic elements, carbon, hydrogen, oxygen, and nitrogen. These sub-

stances have had given to them a variety of names, but they seem to have a common basis which is called *protein*. Hence they are collectively spoken of as protein or proteinaceous matters. Protein is always found in the interior of the cells of plants. It is sometimes in large quantities, and sometimes in small, but always there. It is possible for a cell to exist without cellulose but not without protein. It forms what is called the cytoblast, the protoplasm, or endoplast. It is around a layer or nucleus of this substance that all cells are formed. It is the seat of all chemical change that characterises the life of plants, and is altogether the most important product which they yield. When the protoplasm is only covered with thin layers of cellulose, such is the effect of its chemical activity, that the cell moves about with facility. Hence it arises that most one-celled plants that live in water have the power of moving.

Fig. 32.

5. The most important function of protein is in its relation to the animal kingdom. It is this substance which, entering into the composition of the food of man and animals, forms the great bulk of the tissues of their body. Muscles, nerves, blood-vessels, and other parts, are composed entirely of protein; and the great object of the process of digestion is the transference of protein from the vegetable to the animal kingdom.

Protein is found in the animal kingdom in three principal forms, and called albumen, fibrine, and casein. It can be obtained from plants in these three forms, and they have been called vegetable albumen, vegetable fibrine, and vegetable casein. Albumen is found dissolved in the juices of plants, from which it is coagulated by heat or nitric acid. Fibrine is found in the flour of wheat and of the other cereal grasses, from which it may be obtained by washing away the starch. Casein is found in the seeds of leguminous plants, as peas, beans, and lentils. These substances are said to differ from each other according to the quantity of sulphur and phosphorus they contain combined with the protein.

6. The *non-assimilable* substances found in plants under the influence of vegetation are a very extensive class. Whatever compounds distinguish particular plants, or groups of plants, and cannot be referred to the assimilable groups, find a place amongst them. Some are very generally present in plants, as chlorophyle, whilst others are only found in particular species, as morphia and gutta pertsha; they are, however, like the preceding, always formed of two, three, or four of the organic elements.

7. The beautiful green colour of the leaves of plants, which gives so great a charm to the scenery of our island in the summer, is dependent upon a green substance found in their cells called chlorophyle. Sometimes this substance is found forming a layer on the interior of the cells, sometimes granules of it adhere to the cell walls in a spiral form (fig. 33), but in most instances the granules are free in the interior of the cells. Generally it is found only in those parts of plants exposed to light. When deprived of light, the parts of plants do not develop chlorophyle, they are then said to be *etiolated*. In the growth of asparagus, sea-kale,

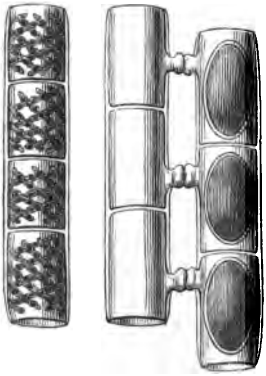


Fig. 33.

celery, and some other plants, the gardener purposely deprives them of light; and the absence of chlorophyle is attended with the absence of other secretions that would render those plants uneatable. From some unaccountable circumstance, the leaves of the branch of a shrub or tree sometimes become etiolated, and they are white, or yellowish white, or partly green and white. If these branches are cut off, and allowed to grow, they always produce the same kind of leaves: such plants are called variegated. Amongst those subject to this change are the holly, the privet, the box, and the china-grass. Some plants are permanently variegated, as the Portuguese Laurel. (Fig. 34.)

8. Chlorophyle, which is also called *chromule*, *phytochlor*, and *endochrome*, is a compound of the same organic elements. The basis of this substance is wax, which is combined with a green colouring matter. This green colouring matter contains the nitrogen, and according to its abundance, in proportion to the wax, is the intensity of the green. It is very susceptible of chemical change, producing other colours besides green; and it is thus we can account for the varied colours of many leaves, and the tints which they assume in autumn. The colours of petals also appear due to chemical products of a similar nature to the colouring matter of the chlorophyle.

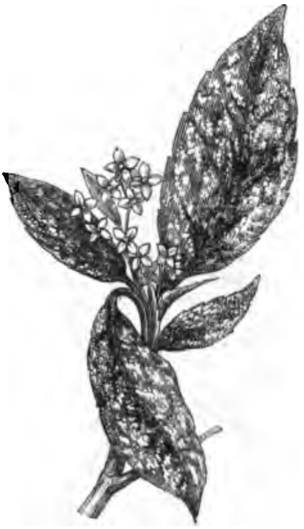


Fig. 34.

9. It was at one time supposed that chlorophyle

assisted in the absorption and decomposition of the carbonic acid taken up by the tissues of plants, but it is now known that this process goes on quite independently of it. The colourless parts of plants are as much nourished by carbonic acid as any other. Chlorophyle, like other products, is probably the result of the decomposition of other substances; and we may find in the composition of starch and protein the materials for the production of this widely-diffused compound.

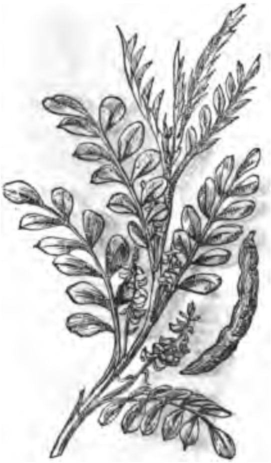


Fig. 35.

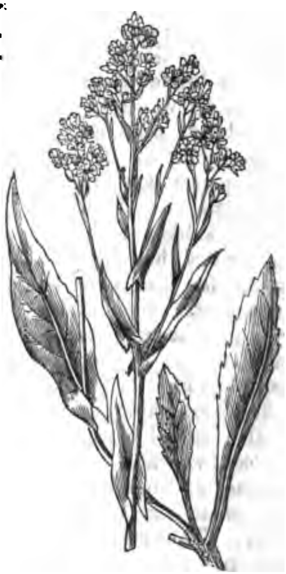


Fig. 36.

10. The obvious colours of plants we have seen to depend upon the presence of chlorophyle; but there are other colouring matters in plants not obvious to the eye, and about whose nature there is considerable uncertanty. The substance called indigo, which is obtained from the Indigo Plant (fig. 35), and from the Woad (fig. 36), the plant with which the ancient

Britons coloured their naked bodies, resembles in its composition the colouring matter of chlorophyle. Indigo, as it is used in the arts, does not exist naturally in these plants, but is formed from them subsequently by a chemical process. In the same way the colouring matters obtained from plants, which are used so extensively in the dyeing of silk, cotton, linen, and woollen goods, do not exist as colouring principles in the plant, but develop this property in contact with various chemical reagents, after they are extracted from the plant. Such is the nature of the dye contained in the roots of the Madder (fig. 37), the Logwood, the Sumach, the Safflower, the Cudbear, Fustic, Saffron, and a hundred others. Most plants contain peculiar colouring matters belonging to this class; so that from many of the common weeds of our hedges substances can be extracted, affording, with the mordants of the dyer, the most varied and beautiful colours.

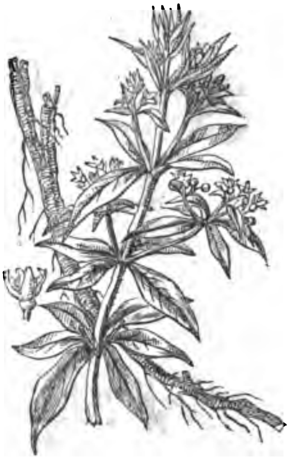


Fig. 37.

LESSON VI.

COMPONENTS OF PLANTS—*continued.*

> ———" Off at sea, north-east winds blow
> Sabean odours from the spicy shores
> Of Araby the bless'd."

1. The vegetable acids are numerous. The best known are those which occur in the fruits and other parts of plants which are eaten on account of their

acidities. Oxalic acid is found in many plants, as the Wood-sorrel (fig. 38), after which it is named, the common Sorrel, and the various species of Rhubarb. It is, as we have before said, remarkable for forming an insoluble salt with lime, which is often found in plants, constituting raphides. Citric acid is the acid of lemons, oranges, limes, and shaddocks. Tartaric acid is found in grapes and many other fruits. Malic acid gives sourness to pears, apples, and the fruits of the Rose tribe generally. Most of the alkaloids are combined with peculiar acids: thus morphia, the active principle of opium, is found combined with meconic acid, aconitina with aconitic acid, and so on. One of the most powerful poisons found in the vegetable kingdom belongs to the group of acids. This is hydrocyanic acid. It is found in almost all the plants belonging to the Almond tribe. It has been lately discovered to be present in the poison of the Tapioca plant (fig. 39).

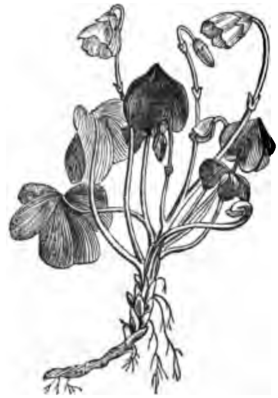


Fig. 38.

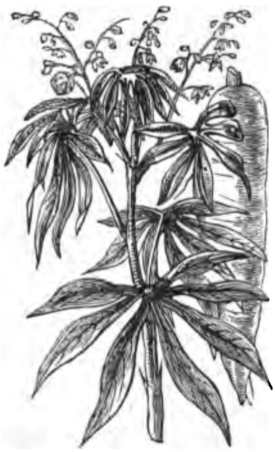


Fig. 39.

2. There are two acids so peculiar as to demand a separate notice; these are *tannic acid* and *gallic acid*. The first is also known

by the name of *tannin*, and is the substance in oak-bark, which, uniting with the gelatine of skins, converts them into leather. It is found to be capable of uniting with the alkalies and forming salts, thus proving its claim to be regarded as an acid. It exists in a great number of plants, either combined with other substances ,or assuming modified forms. It is used extensively in medicine; and a large number of plants possessed of medicinal virtues owe their properties entirely to its presence. As investigation gradually revealed its presence in other plants besides the oak, a large number of them are now used in the art of tanning. The substances kino, and catechu or gambir, are almost entirely composed of tannic acid. The former is an exudation, the latter an extract obtained from many trees. Various barks and fruits are imported into England for the purpose of being used in tanning.

3. Tannic acid is so very general a constituent of plants, that we must look for an explanation of its occurrence in some general condition of the vegetable system. If the elements of cellulose are compared with those of tannin, it will be seen that no very great amount of change is necessary to convert one into the other, and certainly not more than we know to be of constant occurrence in the vegetable kingdom.

	Cellulose.	Tannin.
Carbon . . .	12	18
Hydrogen . .	8	5
Oxygen . . .	8	9

4. Gallic acid is found under the same circumstances as tannic acid; in fact, gallic acid can be produced by the oxidation of tannin. This acid is found more especially present in the excrescences called galls, found on several species of oak. One species, called the gall-oak, supplies by far the largest quantity of galls. These curious excrescences are formed by the agency of an insect, which, depositing its eggs in the bud of

the plant, causes it to grow into a gall instead of a branch. The oak-apples, worn by boys on the 29th of May, and the robins'-pincushions, found on rose-bushes, are examples of the same sort of thing. Gallic acid is used extensively in the arts; it forms a black compound with iron, and is used for dyeing black. Writing ink is also made by putting into an infusion of galls a salt of iron.

5. The alkaloids of plants, though not very conspicuous in their structure, are physiologically of high interest. Some of these substances characterise groups of plants, whilst others again are only found in a particular species. Many of these alkaloids act powerfully on the human system, and produce even destructive effects. Some orders or families of plants are remarkable for producing them. Thus we find, in the Deadly Nightshade tribe, henbane, tobacco, stramonium, deadly nightshade, and others, all yielding poisonous alkaloids. The Crow-foot tribe is another group of plants yielding aconitina, delphinia, and other alkaloids, and the whole family is consequently to be suspected. Many other examples might be given.

6. Although not alkaloids, because they do not combine with acids, we may refer here to a class of substances which, many of them, act on the human system as powerfully as alkaloids. As a type of these substances, theine, the active principle of tea, coffee, and Paraguay tea, may be taken. At first these plants were supposed to produce three different principles, but they are now known to be the same thing. This is interesting as pointing out the fact that tea and coffee are consumed on account of the action of theine on the system. It is a curious fact that chocolate or cocoa is found to contain an analogous principle called *theobromine*.

7. The group of *volatile oils* and *resins* here demands our attention. When their general composition is looked at, they have an undoubted relation to the fixed oils; but they are very varied, and the facility with which they are evaporated, and the remarkable scents they

produce, constitute them an undoubted class. Volatile oils assume a variety of characters. They are sometimes solid, as camphor; of delicious scent, as the oil of roses or orange flowers; disagreeable, as in anise and assafœtida. Some are inflammable, and used for light and heat, as the oil of turpentine, which is yielded by the Pine tribe, where it exists with resin which is dissolved in it. Some are employed as spices, as cinnamon, cloves, nutmeg, and allspice; others as condiments, as pepper, mustard, onions, caraway, coriander, fennel, thyme, mint, balm, sage; others again as medicines, as cajeput, copaiba, camphor, rue, valerian, anise, dill, cumin, and many others.

8. Most of the resins and gum-resins used in medicine, as myrrh, galbanum, assafœtida, turpentine, and others, owe their properties to the volatile oils they contain. Volatile oils arrest decomposition. Sugar will not ferment where they are present. Paste does not become sour if they are added to it. Animal matters are preserved by creosote. It may be a function of the volatile oils in plants to arrest decomposition. At the time of the greatest fragrance the air is purest; and malaria and miasm are given off from vegetable matter when the season of flowering is over.

9. The last group of the non-assimilable substances to which we need refer is that of the hydro-carbons. This name is given to India-rubber and gutta pertsha, because they consist of nothing but hydrogen and carbon. Their chemical composition is not very definite; but the chemist has succeeded in obtaining from them a number of very interesting chemical compounds. India-rubber or caoutchouc differs from gutta pertsha in being much more widely diffused throughout the vegetable kingdom. Whatever plants possess a milky juice contain caoutchouc. There are many natural orders which are thus distinguished. Common examples of this kind in our own country are the Dandelion, the Sow-thistle Spurges, and the Celandine. The India-rubber of commerce is now obtained from a variety of plants, and

from all parts of the world. It was originally yielded by the India-rubber tree (fig. 40), a native of the East Indies.

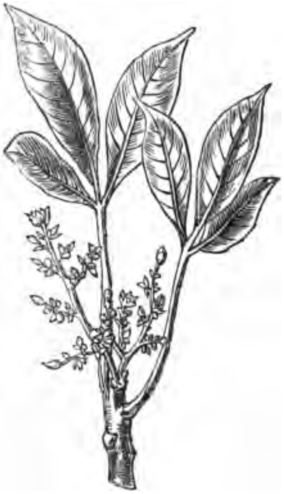


Fig. 40.

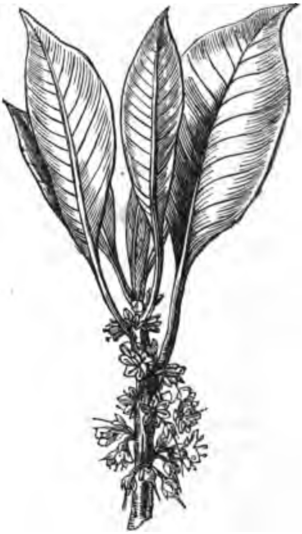


Fig. 41.

10. *Gutta pertsha* is the produce of a plant (fig. 41), growing in great abundance in certain parts of the Malayan Archipelago and coasts of Singapore. Unlike India-rubber, it is not found in the juices of the plant, but deposited in the tissues of the wood and bark. It is brought into this country in solid masses, and has the singular property of becoming soft without being adhesive at the temperature of boiling water. This property renders it very useful in the arts for moulding and other purposes.

11. This sketch of the materials of which plants are made will prepare us to enter upon the study of their structure and functions. In studying the complex

structure of vegetable organs, and the functions they perform, it is necessary to bear in mind that every part assumes its peculiar actions under the influence of the properties of the elements and their compounds of which it is formed. At the same time, from reflecting on the wonderful variety obtained in the vegetable kingdom through the agency of a few elementary substances, a lesson may be learned of the wisdom and goodness of God, who in all these arrangements has contemplated the happiness and advancement of man.—EDWIN LANKESTER.

Animal Physiology.

BY ROBERT JAMES MANN.

LESSON I.

1. WHAT IS AN ANIMAL?

"I will praise Thee, for I am fearfully and wonderfully made."

1. IT is always a pleasant occupation to notice the beautiful forms that are spread abroad upon the surface of the earth; but this pleasure is converted into a profitable enjoyment, when the observer is able to think about what he sees, as well as to look thereon. Every object in nature has some lesson either of knowledge or wisdom to impart, if the eye is but directed towards it in the right way, and the mind has been sufficiently instructed to be able to perceive what is there. The careful and attentive observation of things is one of the first and most important steps in the process by which the pitiable condition of ignorance and misery is changed into the enviable state of intelligence and happiness.

2. As we saunter down the garden path this brilliant and agreeable afternoon, let us stop for a few minutes and direct our eyes towards the ground. There is the runner of a strawberry-plant straggling out from the green foliage of the bed, quite across our way. A

small cluster of little leaflets sprouts from this runner, and drops a bunch of fine, thready roots into the air. We will take and fix it lightly by its roots in the mould, for then we shall have done exactly what the strawberry-plant itself is striving to do. Now, if we were to come back and look at our work after a few weeks, we should find that a very great change had taken place during our absence. The little cluster of leaflets would then present itself in the form of a full-grown strawberry-plant, perhaps covered all over with white blossoms, and only waiting for the influence of the sun to ripen them into delicious fruit. This change would have been brought about merely by the plant having drunk in invisible vapour from the air, and liquid matter from the ground, and having converted this vapour and this liquid matter into sap and vegetable substance within its own structure. The structure swells and grows larger, because fresh substance is thus added to the old substance day after day. Whenever any body increases in size by the addition of new material to its inside in this way, it is said to be a *living creature*. Stones are not living creatures, because they lie upon the ground from year to year and never get any larger, or undergo any alteration of internal composition. They are simply dead bodies. But all plants are living creatures, because they become gradually larger and alter their appearance, by adding new matter to their insides.

3. But there is another kind of life, besides the simply vegetating and growing one. If we turn aside some of the green strawberry leaves before us, the chances are that we shall soon discover evidence of this. Look! There is a lurking frog fancying that he has kept himself from notice in the shade. Stretch out your hand quietly towards him, and lay hold upon him. Where is he? Why, he is gone. He has betaken himself to his long legs, and leaped briskly off beyond our reach. He knew as well as we did ourselves what we *wanted*, and has carried himself out of the way of mischief. He prefers hopping about in the grass to

being a prisoner. Observe how he turns his sedate eye warily upon us as he makes for the bushes yonder. It was by the help of that eye that he became acquainted with our presence and our plans. Look at his long, pliant limbs, how he alternately draws them up under him, and then jerks them out, like released springs, to force his weight along. By means of those limbs he roves about at will from spot to spot. If we had caught him we would not have hurt him, because we know we should have been very unhappy ourselves if some great powerful creature, a hundred or a thousand times bigger than we are, had served us in the same way, and we are aware that we have no right to do to others what we should not wish others to do to us. But if we had pinched his skin we should have seen that he felt us, and tried to pull the hurt part away. There are, then, three things that mark animals out from other living bodies that grow and alter their appearance from day to day. (1.) They can feel. (2.) They can observe what is taking place around them. And (3) they can, when they wish to do so, move their limbs upon their bodies and their bodies upon the ground. Plants never feel when they are touched, nor perceive surrounding objects, or move by voluntary and intentional effort. Sensation, perception, and the power of moving, are the great privileges God has given to animals. These are indeed the faculties by which he has made animated frames fit for the accomplishment of the business for which they have been placed upon the earth.

4. Animals feel and perceive through the instrumentality of what is termed their nervous system, and they move, through the operation of what is designated their muscular system, aided mechanically by the rigid parts called the bones. Of these two systems, the former is so delicate and important that in all the more perfect creatures the greater portion of it is packed away in hard cases provided for its safe keeping. The centre of the framework of the body is made of a column of long pieces. These are the spine (*or backbone*) and skull.

But the backbone and skull are hollow throughout, and contain in their insides a mass of soft, pulp-like substance, incased in strong coats of membrane. The part of the pulp that lies within the skull is called the brain, the portion within the backbone is known as the spinal marrow, or spinal cord. Now from this brain and spinal cord, very fine tubular threads, also filled with the pulp, run out, through little holes left for their passage in the long, bony cases, and are then scattered to all the limbs and other parts of the frame. These tubular, pulp-filled threads are designated *nerves*, and carry messages, some of them out from the brain and spinal cord to the limbs and parts capable of moving, others in from the surface of the body to the brain and spinal cord. Those that transmit the messages *from the brain* are named nerves of motion; those that communicate impressions *to the brain*, nerves of sensation.

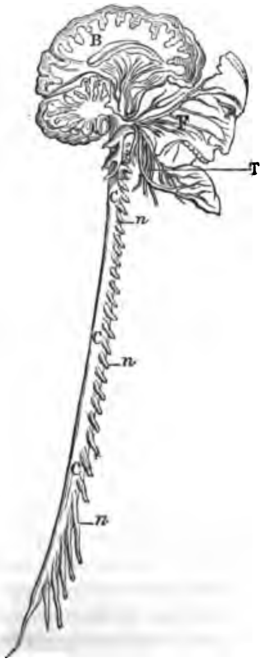


Fig. 1.

The accompanying fig. 1 represents the arrangement of the nervous system. B is the brain which lies within the skull; C the spinal cord lying within the backbone; F the nerves that run from the brain to the face; *n*, *n*, the nerves that run out from the side of the spinal cord to be distributed to the muscles and skin of the various parts of the body, and T, trunk nerves that are supplied to the organs concerned in the nutrition of the body.

5. When I place my finger upon this stone I effect what I design to do, because my brain sends a message to the muscles of my arm and hand through some of the nerve-threads that run thither from it. But I feel the stone to be hard and cold. I am sensible of this because the contact of the stone with my finger makes certain mechanical impressions upon the nerve-threads therein looped about, and these impressions are transmitted through their continuations up to my brain. The whole surface of my body is supplied with nerve-threads, and is endowed with feeling as well as my finger. I am conscious of the hardness and coldness of the stone if it is pressed upon the back of my hand, or upon my forehead, or on my naked foot. But there are other parts of my frame that are endowed with the power of noting very much more subtile and refined impressions than those of simple mechanical contact. I want to know a great deal more about the nature of surrounding bodies than I could learn by this means. In order that I may do so, my organs of special sense have been contrived. These organs, for convenience sake, have been all packed into my face; the face of animals is the great seat of sensory capacity; it is indeed almost entirely a framework covered over with sensory nerve-threads, that are gathered up thence into bundles for the sake of convenient transmission to the brain.

6. Observe in my countenance the eyes half buried in sockets directly beneath the brow and forehead; the nose that projects with its double air-receiving opening immediately over the mouth; and the mouth that is nearly filled with the tongue; notice, too, the ears hung at either side. All these parts are furnished with myriads of nerve-threads inwardly prolonged to the brain, which is situated just over them behind the forehead. Through the eyes, the form, colour, position, and distance of bodies are seen. As I now look at the book before me, I have a perfect image of its form sketched like an exquisite miniature upon the nerve-film that is spread at the back of my eye. If any one could get into my

head behind, and could make the nerve-coverings and skull-walls, that would then intervene between himself and the picture, transparent, he would see it like a drawing laid before him. The drawing, however, is made, not upon paper or canvas, but upon interwoven nerve-threads (as has been already stated), that are capable of distinguishing which parts of the delineation are brightest, and which dullest, and which parts are coloured, and which not. All these particulars are then transmitted by nerve-threads to the brain, each carrying its own message from its own parts of the picture. When the brain receives and notes these intimations, the mere visual impressions in the eye become vision, and I see the object which has given rise to the impression, in all its peculiarities of outline and alternating light and shade, and know a great deal about what it is, in consequence of the sight. So, again, if I were to wish to cause any other person to look at the book, I should ask him to do so, and the tones of my voice would then be carried to his ears as little vibrations, or waves of air, and the delicate nerve-threads contained within those organs would distinguish the force with which each successive vibration tapped upon their extremities (somewhat as sea-waves knock upon the rocks of the coast), and so mark the difference of each successive tone, and communicate the result to the brain. Invisible particles of odorous substances also float into my nose with the air, and excite the sensations of scent. Soluble substances that are masticated in my mouth produce the sensations of taste.

7. It is in this way, then, that I and other living animals get information regarding surrounding things. Organs of sensation receive material impressions, nerve-threads convey intimations of these impressions to the spinal cord and brain, and the brain converts them into conscious perceptions. When perceptions have been completed, the brain issues its orders regarding what is to be done under existing circumstances. These orders are communicated to the muscles by motor

nerve-threads, and the muscles work the jointed limbs until the orders are obeyed. The muscles are nearly all cords stretched between long pieces of bone, that are connected together by joints, and they are attached and arranged in such a way that the bones may be caused to play backwards and forwards on their joints, when the muscular bands are shortened, just as a door might be made to play backwards and forwards upon its hinges, by two persons shortening alternately ropes extended from its handle opposite ways. The muscles, nerves, organs of sense, and brain, are the apparatus of *animal life.*

The most perfect animal might be made up entirely of a jointed skeleton, supporting and carrying these parts, and covered in by skin, if it were not for the fact that all the parts require to be fed from time to time. The muscles and nerves will not continue to work without frequent supplies of nourishment, any more than a fire will continue to burn without frequent additions of fuel. Hence other parts are added to the skeleton, and muscular and nervous systems, to attend to this portion of the business; such parts however, do nothing else but arrange and regulate the supplies. They constitute the apparatus of *organic life.* The body of the sedate and wary frog contains all these wonderful arrangements and contrivances; and it is, therefore, that when we advance our hands to lay hold of him, the prudent fellow is able to hop off out of our way.

WHAT IS LIFE?

An eagle flew up in his heavenward flight,
Far out of the reach of human sight,
And gazed on the earth from his lordly height
In the clouds of the upper air :—
And this is life, he exultingly screams;
To soar without fear where the lightning gleams,
And look unblenched on the sun's gorgeous beams,
And know of no harrowing care.

It is life, said a whale, to swim the deep;
O'er hills submerged and abysses to sweep,
Where the gods of ocean their vigils keep
In the fathomless gulf below:—
To bask on the bosom of tropical seas,
And inhale the fragrance of Ceylon's breeze,
Or sport where the turbulent waters freeze
In the climes of eternal snow.

It is life, I hear a butterfly say,
To revel in blooming gardens by day,
And nestle in cups of flowerets gay,
When the stars the heavens illume:—
To steal from the rose its delicate hue,
To sip from the hyacinth glittering dew,
And catch from the beds of the violet blue
The richest and sweetest perfume.

It is life, said a savage, with hideous yell,
To roam unshackled the mountain and dell,
And feel my bosom with majesty swell,
As the primal monarch of all:—
To gaze on the earth, the sky, and the sea,
And know that like them I am chainless and free,
And never, while breathing, to bend the knee,
But at the Manitou's call.

An aged Christian went tottering by,
And white was his hair and dim was his eye.
And his broken spirit seem'd ready to fly,
While he said, with faltering breath—
It is life, to move, from the heart's first throes,
Through youth and manhood to age's snows,
In a ceaseless circle of joys and woes:—
It is life to prepare for death.

* * *

LESSON II.

ORGANIZED STRUCTURES.

"Like as a father pitieth his children, so the Lord pitieth them that fear him." . . . "For he knoweth our frame; he remembereth that we are dust."

1. WALLS are built up of mortar and bricks, and on this account they are *structures.* Whatever is made

of separate parts put together for the purpose is termed a structure, the name being derived from a Latin word which means *built*.

The bodies of plants and animals are structures, because they are built up of separate parts put together for their formation. But the parts of which plants and animals are constructed, are not hard, solid bodies like the bricks used in making walls. They are thin bags or balls of soft filmy membrane, filled inside with fluid. Imagine the case of a great number of the common hollow India-rubber balls piled up into the shape of a wall and then held in their places by strong coverings of netted ropes. Such a pile might still be called a wall, and might answer some of the purposes to which walls are put, but there would be certain other conditions present in it that would fit it for uses to which ordinary walls are not suited. It would be soft and yielding, for instance, instead of being hard and firm, and might be pushed a little this way or that, without being broken or destroyed.

2. Under certain circumstances, also, liquids might be made to pass from one part of the pile to another, through the walls of the bags or balls. Imagine that these balls, instead of being composed of India-rubber, were formed of a stout, strong paper that would not allow water to drip through merely by its weight, but that, nevertheless, soaked it up into its substance. If a ball or bag, of stout paper of this kind, were filled with thick syrup and hung upon a nail in a wall, the syrup would be retained in it as thoroughly as if it were held in a glass bottle; none whatever would escape. But now, suppose that this bag of syrup were taken down from its nail, tied up closely round the mouth, and placed floating on salt water contained within a pail. Then on the morrow it would be found, even although the stout paper had been nowhere injured or torn, that some of the salt water from the pail had got into the syrup in the bag, and that some of the syrup from the bag had passed out to mingle

with the salt water. Under such circumstances, the film of paper really helps the syrup and salt water, between which it is placed, to mix, instead of preventing them from doing so. Both the syrup and the salt water soak into little invisible pores of the paper, that are large enough to allow this soaking, although they are not large enough to permit particles of liquid to drop through by the mere influence of weight. Some of the soaked-in syrup then passes from the outer surface of the paper bag into the pail, and some of the soaked-in salt and water passes from the inner surface of the paper into the syrup, fresh salt water and fresh syrup being at the same time soaked up into the paper to take the place of those removed. This goes on, and a continued passage of the liquids through the paper takes place, until that in the pail and that in the bag are reduced each to the same admixture of syrup and brine. In this way, then, salt water poured into a trench dug round a wall made of stout paper bags filled with syrup, instead of being formed of India-rubber balls, would slowly find its way up through the syrup to the top of the pile.

3. There is yet another thing that may be imagined with regard to this pile of bags. It is quite possible to fancy that every bag in the heap is alive, and that its life is shown by its being able to produce a brood of little bags, of similar nature to itself, in its inside. First, let it be conceived that several little dark specks appear floating in the syrup contained in the bag; that these spots then feed on the syrup and grow until they become themselves small hollow bags of membrane; that the growth continues until the newly-formed bags become so large that they entirely fill up the inside of the original one, and at last burst it, and escape from their imprisonment. The old bag is then broken up and destroyed, but, instead of it, there are several vigorous young ones, each capable of going on growing until it becomes as large as the parent, and is in its turn ready to produce its own brood in the same way. The

entire pile of bags would thus keep getting larger by a swelling out of its substance in all its parts. It would, in fact, grow. But now, once more, suppose, that while all this is going on, some of the newly-formed bags are altered in various ways after they have obtained their full growth, and are packed together in different fashions, one portion wedged densely together until they constitute a rigid mass, another portion being lengthened out and laid end to end until they compose fibres and tubes, and another arranged so as to form partitions, the sides of cavities, and fabrics of every variety of appearance; the substance, out of which all parts thus formed are produced, being in the meanwhile derived from the liquid, sucked in by the bags from some external reservoir with which the coats of a portion are in contact, and the netted ropes which bind down the expanding pile being stretched from time to time to permit its increasing dimension. Then the pile would really be a living and growing body, augmenting its size by the addition of new matter to its inside, and there forming structures of several different kinds. It would indeed be a sort of plant, if the newly-made bags were packed into the form of stems and branches and leaves.

4. Plants are nothing else but piles of living bags of this kind, able to multiply by the production of new bags, in their interior cavities, and to draw the nourishment they need for the construction of these new generations of bags from appropriate liquids that are placed in contact with some convenient part of the pile. The bags of which plants are composed cannot, however, be seen by the naked eye, because they are exquisitely small. They are so very minute that from a quarter of a million to a million of them may be laid out, side by side, on the face of a shilling. With the help of the microscope, they can nevertheless be discerned in all their singular varieties of arrangement and form. Under certain favourable circumstances, they may even be seen producing their young broods and new generations, in

their insides. The living bags of membrane that are thus used, instead of bricks, in the construction of plants, are called *cells* or *vesicles*. The word cell is borrowed from a Latin term, which signifies a chamber wherein things may be stowed or concealed. Vesicle is taken from the Latin name for a part of the animal frame that is made like a bag. It therefore is, of the two, the more expressive and appropriate term.

5. But exactly in the same way, the bodies of animals are constructed of little living bags or vesicles, which multiply by forming young broods in their interiors, and which grow and get altered into various forms that they may be fit for different uses; some get crammed with lime and built into pieces of a bony skeleton—others pour out a sort of cement all round and then fix themselves therein, to constitute gristle or cartilage; others are moulded into tubes that are designed to carry digested nourishment and blood through the system; others are woven into fibrous bundles and interlaced net-works, to compose the tendons that bind bones together and muscles to bones, and the sheets and bands that connect the several parts of the frame into one continuous whole; others are clustered into glandular bodies, such as the liver and the lungs, that separate impurities from the blood, or store away its superfluous ingredients as fat. Others are ranged into layers to make broad membranes that line the different cavities and cover the general outside with a protecting investment of skin, and yet others are transmuted into the contractile muscular fibres that work the bones, and into the delicate nerve-pulp that converts external impressions into sensations and perceptions, and that originates mental influence. All these animal vesicles are also very minute, and require that powerful microscopes should be employed in looking for them, before they can be seen. The vesicles that form fat are amongst the largest of them, but of these as many as half a million might generally be laid flat, and side by side, on the face of a shilling. In the following delineation, *a* shows

the appearance the vesicles of fat wear, when they are viewed by the microscope; *b* is a magnified view of the vesicles of young and just-forming gristle; *c* represents the vesicles in older gristle, when they have imbedded themselves in their cartilaginous cement; *d* is a magnified view of bone-cells thickened and consolidated by their deposits of lime.

6. The human body, then, is a vast heap of very minute vesicles piled together, and altered in various ways, as shown in fig. 2, in order to fit them to form bones, joints, tendons, blood-vessels, glands, muscles, nerves, brain, skin, and other less important parts. But every one of these differently-constructed portions of the frame has its own proper offices to perform, and these are offices which none of its neighbours can accomplish, although the accomplishment is essential to the wellbeing of the whole. The bones, joints, tendons, and muscles effect the movement of the body from place to place; the blood-vessels circulate the blood, the glands keep the circulating fluid pure, the nerves and brain aid the powers of sensation, perception, intelligence, and will. Each distinct part of the frame is an ***instrument*** planned for the performance of a certain work, and is on this

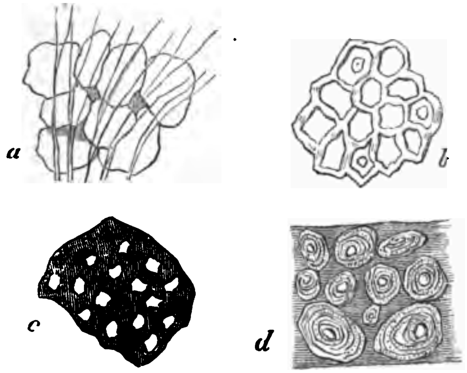


Fig. 2.

account called by a name that is derived from the Greek word that signifies an instrument. It is termed an *organ*. The heart and brain, the lungs and liver, the muscles and nerves, are all organs of the body. The body is, therefore, not only a *structure*, a thing built up of subordinate parts; it is also an *organized structure*, a frame built up of subordinate parts that are individually organs or instruments. But these organs are also themselves composed of subordinate parts, which are little vesicles, and these vesicles are individually living bodies capable of growing from germs, of feeding, maturing, and producing other vesicles like to themselves. Each of these vesicles is, therefore, an instrument or organ in itself, and the organs made up of them are consequently organized structures. But, as the vesicles are continually dying off, and new ones are as constantly forming, the substance of the organs is always undergoing change. No organ is to-day formed of exactly the same vesicles and matter that composed it yesterday. It is this constant internal change of substance that constitutes the life of these vesicles; so, in the same way it is the constant change and activity of the substance of the compound organs that constitute the life of the body. When, therefore, it is said that plants, and animals, and men are living organized structures, it is intended to express that their bodies are built up of instruments, which are each composed of separate living parts. This life which results from the activity of the little organizing vesicles is, however, designated *organic life*, to distinguish it from the higher kind of *conscious animal life*, which is entirely dependent upon the operations of the nervous system and of the mind.

LESSON III.

HOW ANIMALS LIVE.

"Who satisfieth thy mouth with good things; so that thy youth is renewed like the eagle's."

1. ANIMALS live through the destruction of the organized substance of their bodies. They wear down and waste this, dissolving it into the rude elements out of which it was originally formed, in order that they may acquire vital power out of the change. The hard bones and dense tendons undergo very little further alteration when they have been once fully consolidated, but these parts constitute an exception to the general rule, and are indeed to be looked upon in the light of mechanical additions made to the system for purposes of convenience, rather than in that of essential living portions. All other organs, however, really possess life, and have to pay the penalty of submitting to a continual wear, as the price of the endowment. The hand cannot be raised to the head without the destruction of a certain quantity of muscular substance. External impressions cannot be converted into sensations, neither can the mind be exercised in the operations of thought, without the waste of a proportional amount of nervous material. The glands and vessels, the membranes and skin, all obey the same law, so long as they retain their privileges of being vital and active structures. Every instant, thousands of the little vesicles, of which the parts of the body are built up, die and disappear from the scene; nevertheless, the body, thus constantly undergoing destruction, does not waste, for thousands of new vesicles take the places of the old ones, as they depart. The living body is renewed as fast as it is worn away. The new vesicles, it will be remembered, are all formed as young broods, in the inside of the old ones, before these decay. But these new vesicles cannot be thus made out of nothing. Their material must be procured from some source or other. It cannot be derived from the matter of the old vesicles,

because all that matter is dismissed from the frame as worn up and useless substance. The material for the new vesicles is furnished from the food. Animals eat that their constantly-wasting organs may be renewed, and that they may continue to live.

2. The food that animals use is very nearly of the same nature as the substance of their bodies. Plants prepare this nutritious substance, purposely for their support. When green leaves, growing in the field, imbibe the vapours of the air, and the fluids and salts of the ground, and convert them into succulent turnips, it is that oxen may feed upon those turnips, extract their richer parts, and pack them away in their own skins as flesh, destined in its turn to become beef under the butcher's hands. When the serried ranks of green blades, with the sun's aid, change the same crude elements into golden corn, it is that man may make bread of the corn, and transmute the bread into his own flesh and blood. There is nothing in beef and bone that grass and turnips do not contain, in a more diluted and scattered state. There is nothing in flesh and blood that the chemist cannot extract from corn and bread. But turnips, or meat and bread, are not in a convenient form for immediate conversion into living structure, although they are the right material. They are bulky and solid, whereas the nutriment of the animal frame must be liquid and easily moveable when it is introduced, in order that it may be readily distributed through the system in small streams, as water is poured to the various chambers of a house through pipes.

The solid food is dissolved by what is called the process of *digestion*, a word derived from the Latin term, that signifies to loosen or divide. It is first ground down in the mouth by the action of the teeth, and mixed with the saliva into a sort of pulp. The pulp is conveyed into a large bag or stomach, and there churned up with a solvent juice poured out from the walls of the organ. The mingled pulp and juice are then pushed forward into the long, twisted, intestinal canal or bowels, in which the stomach ends. Here the mass comes into communication with a thick, yellow liquid, termed the bile, which runs into the bowels through an orifice in its wall. After this final addition, the digested substance separates into two parts, of which one is solid and refuse, and of no further use. The other is a clear liquid, something like milk, and contains the nutritious principles of the food in a fluid condition, and ready for conveyance through the narrow canals of distribution. This nutritious, milky-looking liquid is drunk up through small pores in connection with the wall of the bowels, and is then carried through a series of little pipes into one large channel, which terminates within the chest, in the great blood-vessel that runs into the heart.

4. The blood is principally formed from the dissolved nourishment that is thus provided by the digestive apparatus, from time to time. It is contained in a system of ramifying pipes or tubes, which issue, first, as large trunks from a hollow, muscular, forcing pump, called *the heart*, and which then run to all parts of the body, branching out more and more as they go, like the ramifications of a tree, until at last they become merely fine, hair-like twigs netted together, and scattered in this form through every structure of the frame. The accompanying sketch (fig. 3,) represents the appearance of these fine, hair-like twigs of the blood-vessels as seen with the help of a microscope. They are termed the *capillary vessels*, the name capillary being taken from a Latin word which signifies a hair.

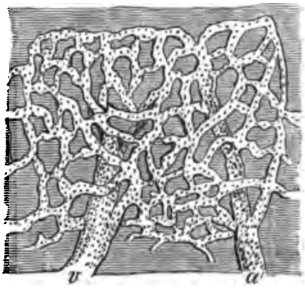


Fig. 3.

5. But there are two distinct series of large blood-

vessels connected with the heart, the one series designed to carry the blood out from its cavity to the capillary tubes, the other to bring the blood back from the capillary tubes to the heart. Let it be imagined that a couple of large forest trees are planted side by side, and that all the twigs and leaves of one are united to all the twigs and leaves of the other, instead of both being hung out independently in the air; and that the sap is forced up from the ground through the trunk of one tree, and through its branches, into the fibres of the conjoined twigs and leaves, and thence still onwards into the branches and trunk of the other tree, and at last through this trunk also, and back into the ground. This is exactly what happens with the animal blood-vessels. There is a great trunk which starts from the heart, and is branched out to the capillaries, and there is a great trunk which is gathered in from the capillaries to the heart. The trunk and branches, which carry blood from the heart, are called *arteries*, because, when they were first noticed in dead bodies, it was observed that they were always empty, having really forced their contents onwards at the moment of death; hence they were conceived to carry spirit or breath during life, and received the designation, which signifies in the Greek language, the reservoir of the breath. The trunk and branches which convey the blood back to the heart are, on the other hand, termed *veins*, because they are nearly always found to be full of black, clotted blood after death, and consequently look like fibres. The word vein is taken from a Greek term that signifies a fibre. In the preceding figure (p. 153) an artery is shown at *a* branching into the net-work of capillary vessels; a vein is drawn at *v* returning from the same towards the heart: in the subjoined sketch the appearance of the heart is represented, with the commencement of the great vessels that carry blood outward from or inwards towards its cavity.

6. As the blood is brought back to the heart after it has passed through the capillaries, it must of necessity

start for a fresh journey so soon as it has returned. The heart (fig. 4,) dilates to receive a charge of blood from the veins, and then contracts upon its charge to force the same on into the arteries, and this goes on again and again. There are valves placed at all the openings of the heart, which allow the blood to move in one direction when the organ contracts, but prevent its moving the opposite way; thus the onward flow of the blood becomes a true circulation. It passes round from heart to capillaries, and capillaries to heart, again and again. The alternate dilatation and contraction of the organ takes place seventy or eighty times every minute. By these frequent strokes, about thirty pints of blood—the quantity the body of a full-grown man contains—is pumped through the heart every two minutes. In twenty-four hours, the entire thirty pints of blood circulate through the heart and capillaries, over and over again some seven hundred times. Each part of the body is, consequently, abundantly supplied with this important material of nourishment.

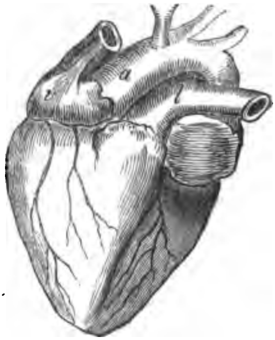


Fig. 4.

7. The blood is a very rich plastic fluid. It is quite liquid when it is drawn from a blood-vessel, but a portion of it then very soon gathers itself into a firm clot of solid matter. Now, it is out of this plastic, readily-coagulable part that the little vesicles and their contents are mainly formed. As this tenacious material is brought to them by the small capillary tubes, they seize upon as much as they want, moulding it into their own likeness, and fabricating out of it films and fibres of various kinds. The worn-out substance of the dead vesicles is also taken into the capillaries, and is so

carried through them again into the general circulation. But this useless matter is very soon separated from the blood by what are called secreting organs, provided purposely to effect such purification. It is in this way that animals are enabled to live, and perform voluntary movements, and experience sensations and perceptions, through the continued waste and renewal of organized structure, until, at an advanced age, the little vesicles of their bodies cease to be able longer to multiply themselves, and so natural decay takes the place of growth and repair.—ROBERT JAMES MANN.

* * *

THE WORLD TO COME.

If all our hopes and all our fears
Were prison'd in life's narrow bound,—
If, travellers through this vale of tears,
We saw no better world beyond,—
Oh! what could check the rising sigh,
What earthly things could pleasure give?
Oh! who could venture then to die—
Or who could venture then to live?

Were life a dark and desert moor,
Where mist and clouds eternal spread
Their gloomy veil, behind, before,
And tempests thunder overhead:
Where not a sunbeam breaks the gloom,
And not a flower smiles beneath,—
Who could live in such a tomb?
Who dwell in darkness and in death?

And such were life without the ray
By our divine religion given:
'Tis this that makes our darkness day—
'Tis this that makes our earth a heaven.
Bright is the golden sun above,
And beautiful the flowers that bloom;
And all is joy, and all is love,
Reflected from the world to come.

BOWRING.

Ethnology.

BY ROBERT GORDON LATHAM.

LESSON I.

HOW TO OBSERVE THE VARIETIES OF THE HUMAN SPECIES.

> "And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitations."

1. AT the head of the animal world stands MAN; and MAN is, above all other animals, the lord and master of the earth's surface. Yet few zoologists describe the numerous varieties into which the human species is divided. They form, indeed a separate branch of study. There is no part of the world, however, which does not exhibit some of them; in other words, *man is found everywhere.* Of no other species can this be said. It can be said of no fish that it is found in every river, or in every sea, in every river and every sea alike—of no quadruped that it is equally native to the dreary treeless tundras and marshes of the arctic circle, and the wood-encumbered zones of the tropics—of no bird that its range of habitation stretches from the polar regions to the equator. Even the birds of passage have narrower limits than these for their most extended migrations—strong of wing and swift of flight as they may be. The naturalists tell us this, and upon this they all speak alike. No animal lower than MAN is found, at one and the same time, in every region and in *almost* every altitude. I say *almost*, because the regions of perpetual snow are essentially and necessarily uninhabitable. But below these regions, below the circles where vegetation ceases and water becomes ice, man appears, at once, as an occupant; no matter whether the ground be a mountain-valley overshadowed by trees and rocks, or an elevated table-land—exposed, treeless, shadeless. At one season or the other all such spots become inhabited; in spring or summer, if not in winter and autumn. For some varieties of the human species

are essentially wanderers, and move from spot to spot as the seasons change, and as the grass grows. Their herds go with them, seeking for fresh pastures—for almost all the tribes that do this are herdsmen and shepherds, rather than tillers of the ground.

2. The more a man travels the more he will see of these varieties; so that the sailor, the merchant, or the soldier, should be well-informed in respect to the different varieties of the human species. They go over the greatest amount of ground, and may observe either in the east or the west, the north or the south; may see with their own eyes, Negroes, red Indians, Esquimaux, or South Sea Islanders; may hear with their own ears strange and new languages; may speak from their own experience of manners, customs, and dispositions. They have the best opportunities for doing this. But they do not always do it. They are too often deficient in the power of observation; so that they see without marking, and hear without heeding. They fail, too, to see points of likeness when they are ever so slightly concealed, and they exaggerate points of difference when they are, really, of very little importance. This is because they have never considered what they were likely to find, or what they should look out for. The eye of the portrait painter has to be trained; otherwise he fails to catch the points that distinguish one man's features or expression from another. This must be done to distinguish between individual and individual. And the same applies to the observation of national differences—differences of family, or stock. Sometimes they are broad and clear. None but the blind would mistake a Negro. But between the Negro and the Englishman there are numerous shades of difference. The detection of these is not so easy.

3. Now, in this, as in so many other departments of knowledge, we may train ourselves without going abroad —without indeed going far from home. If I live in the country, even in some retired part of it, where strangers and foreigners seldom appear, I may meet in my walks

with a black-eyed, black-haired, swarthy-skinned individual, who, if a female, may want to tell me my fortune; if a male, wish to sell me a dog, or mend me a kettle. There are dark-eyed men of English birth and blood, but this is darker than the darkest of such. The eye is jet black and piercing; the hair straight, and strong, and long; the figure light and well put together. I may walk miles without finding another instance of the like. There is a difference in form, in the colour of the skin, in habits. None such as these keep shops or live in towns. The tent suffices for them—the open air, and the freedom to wander at large. They are *gipsies*. This is a variety that the most retired may fall in with. What makes this gipsy thus vary? why is he so unlike the English labourers of his neighbourhood? He is unlike in make and manners. If we learn a little more about him he shows himself unlike in language also. *We* call him a *gipsy*. He calls himself *Rommany;* that is, a *Roman*. Yet he knows nothing about Rome. *Water* he calls *pawnee*, which is the Indian for that liquid. Then he counts after the following fashion—*one* is *yek; two* is *dy; three* is *tren; four* is *shtan; five* is *pantsh; six* is *sink; seven* is *set; eight* is *okt; nine* is *engya; ten* is *tin*.

4. There is surely something to think about here.—A man in the middle of England calls himself a Roman, and uses an Indian name for one of the commonest objects in nature. Well! I read about him, and find that in Spain, in Bohemia, in Poland, even in Norway, such and suchlike are abundant; and that, whatever be the country in which they are found, they separate themselves from the ordinary inhabitants and use a great number of peculiar words—sometimes a truly separate language. I find, upon inquiry, that this language is the same wherever it is found; so that if a gipsy call *water* by the name of *pawnee* in England, he will also call it *pawnee* in Spain, Bohemia, Poland, or Russia. Surely these numerous tribes must belong to one common stock, and must have spread themselves from

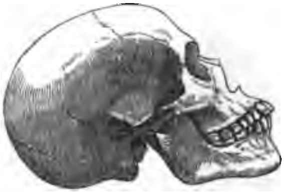
one common spot. They are wanderers at present; but they have not always been so. There was once a time when they had a country of their own, of which all the occupants were gipsies, and where every one called *water* by the name of *pawnee.* What this country was is another question. I am informed that it is some part of India. At any rate, it is to the Indian languages that the gipsy language has the closest resemblance.

5. This has been written to show how even the resident in the most sequestered parts of the country may meet with varieties of the human species, different from the one he belongs to himself. There is no spot on earth where observers may not find something to observe. But great and crowded cities supply, as may be expected, the best opportunities. In London, for instance, we may take such a question as that of the origin of the gipsy into our own hands—we may inquire for ourselves. We may dispense, to a certain degree, with books, and references, and use our own eyes, and our own faculty of comparison only. Most of the ships that come from India bring with them as portion of their crew, some native Indians—sometimes as sailors, sometimes as servants to passengers. Many of these, instead of returning, fix themselves in London; begging, crossing-sweeping, tract-selling, or drug-selling. For a time they preserve their native dress; a flowing robe of white cotton with a turban. When this wears out they adopt the English. But whatever they wear they are distinguished at once from the Englishman. They are dark-skinned, with strong black hair—never light-complexioned. They are darker than the generality of gipsies, but they are more like gipsies than aught else English; and there is nothing in England so like a gipsy as one of the London Indians.

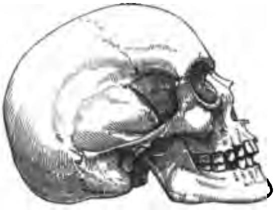
6. But the Indian is only one of the coloured strangers of such towns as Liverpool and London, &c. There are Malays, Manillamen, Javanese, South Sea Islanders, and others. All these are dark-skinned—darker at least

than the ordinary Englishman. All, too, are straight-haired, or nearly so. In this they are like the Indian; so like that it requires a practical eye to distinguish them. But how different they all are from the African, black though the African be. Do we ask wherein the difference consists? Look at the hair. The frizzy, woolly appearance of the African's head distinguishes him, at once, from the Indian or Malay, just as his colour distinguishes him from the European.

7. We may train ourselves, then, to the observation of the varieties of the human species without going far from home. The artist will do it the easiest, for his eye is already exercised. The anatomist will, also, do it easily; for he knows the points that require notice. The anatomist can find food for observation in the skeleton only. Without the aid of the colour of the skin, without the aid of the texture of the hair, he can distinguish between the cranium of different populations; not, of course, with absolute accuracy, and with nice distinctions, but roughly and in the way of approximation. Such a skull as this (A) is probably African; which such a one as this (B) can scarcely be.



A

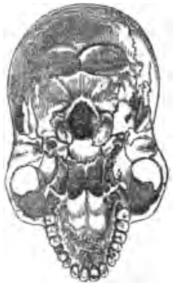


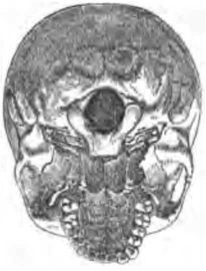
B

8. Observe the diameters from the back of the head to the forehead—from the occiput to the frontal bone to speak anatomically,—the fore-and-aft diameter to speak nautically. There is a vast difference between the two. One gives us a long, the other a short, head. Now the longest heads are those of the Africans, the shortest those of

the Esquimaux and certain populations of Asia and America. The second cranium is like that of the Esquimaux.

9. Then compare the widths of the two skulls at the zygomata, with their respective lengths. How narrow, comparatively, is No. 1. How broad No. 2.


No. 1.


No. 2.

The first belongs to the long, the other to the short skull. As a general rule, the shortest heads are broadest at the zygomata. So that even in museums we can investigate the varieties of our species, clothing dead bones with flesh, and form, and colour.

10. But there is another department, that of the study of the different languages of mankind. Form for form, hair for hair, and colour for colour, the more civilized nations of Europe are alike. They are not absolutely identical, but, upon the whole, they are notably alike. In Northern Germany, in Denmark, Norway, and Sweden, the fair complexions, in Spain, Italy, and Greece, the dark ones, predominate; besides which there are other points of distinction. Upon the whole, however, there is considerable similarity. At any rate there is no such broad contrasts as those between the African and the Englishman; yet the forms of speech differ. The Frenchman (unless he have made it a particular study) understands no English; the Englishman no French; the German understands neither. More than this; without going beyond the limits of Great Britain, we find three mutually unintelligible languages, the Welsh of Wales, the Gaelic of the

Highlands of Scotland, and the English; the numerals in these tongues being as follows:—

English.	*Welsh.*	*Gaelic.*
one	un	aen
two	dau	do
three	tri	tri
four	pedwar	
five	pump	kuig
six	chwech	se
seven	saith	secht
eight	wyth	ocht
nine	naw	nor
ten	deg	deich.

11. There is an arrangement, then, of the varieties of the human species according to their languages, just as there is an arrangement according to the differences of form and colour; and, to show the importance of language as a means of investigation, we may repeat a fact already brought under notice, viz., that it was by means of their language that the Indian origin of the gipsies was demonstrated.

12. Our friend the gipsy has now been brought before us a second time, and we must follow him farther, and learn something more of him. We have spoken about his language, and said that it is peculiar; so it is when it is fully understood. But few English gipsies so understand it; few speak it purely. Sometimes it is almost wholly English, with only a few gipsy (Rommany) words here and there; sometimes there is a fair proportion of gipsy; but, whether spoken well or ill, purely or the contrary, it is a mixed and broken language. How should it be otherwise? No Englishman speaks it at all; so that, ever since the first gipsy put foot upon the soil of Great Britain, the family has been under the necessity of learning English; otherwise it could have had no dealings with Englishmen. Meanwhile the gipsy encampments got smaller and more widely separated from each other.

13. This made the speakers of the original tongue fewer and fewer; and, as in consequence, the necessity of keeping it up grew less. In short it came to be known imperfectly and in fragments.

14. The oldest gipsies know it the best, the youngest the least. What does this suggest? It suggests the likelihood that, within a few more generations, the gipsy tongue in England will be extinct—wholly extinct. We may safely prophecy this; inasmuch as we have observed the processes by which its extinction will be effected. The gipsy tongue, then, is dying out, and will soon be dead; and then, such gipsy words and songs as exist in printed books at the present moment, will belong to what is called a *dead* language.

15. A little consideration will show that what will happen to the gipsy-tongue may happen to others. There are dozens and dozens of tongues thus dying out; some in North America, some in South, some in Africa, some in Asia, some in Europe, some even in the British Isles. Where is this? Look at the Isle of Man, lying at equal distances between England, Ireland, and Scotland. The native tongue of that island is the Manks, a language akin to the Scotch and Irish Gaelic. But this is dying out.

16. Again, in Cornwall, a language akin to the Welsh was spoken currently in the reign of Queen Elizabeth. At the end of the last century only one old woman spoke it—no one speaks it now. But as some specimens of the language were published during the time it was spoken, we know what the old Cornish was; we know that it was closely akin to the Welsh.

17. When the gipsy language shall have become extinct, we shall still be able to separate the gipsy from the Englishman. This we shall do on the strength of the difference of form, features, hair, and colour. But if the Welsh language were dead, this would be no such easy matter, since there is no such difference in the way of conformation between the Welshman and the Englishman, as there was between the Englishman and the gipsy.

18. Hence, language is one of the characters by which the varieties of the human species are distinguished from each other. But it is also a character which may change. Be it so. It leaves, however, traces of its previous existence behind it. We have already said that "even in museums" we can investigate the "varieties of our species." Can we do anything in this way with language? Yes; but instead of the museums we must have recourse to the map and book. We may, in many cases, see how languages are distributed over the surface of the earth by mere inspection of a map. We may do this without knowing anything about the languages themselves; our own mother-tongue being sufficient to begin with.

19. Thus, take a map of England. Look to the counties in it, Lincolnshire and Kent; take the port of Grimsby in the former. Observe the syllable *by* in which it ends: see whether there be any more such terminations in the county; they will amount to more than two hundred—Spills-*by*, Duns-*by*, &c. No single town, village, hamlet, hill, or stream, so ending will be found in Kent. Why is this? Look at the map of Europe. In Germany Proper, no *by*'s will be found, or very few. In Denmark they will be as common as in Lincolnshire. What do we infer from this? That the Danes settled much more in Lincolnshire than in Kent. This is shown by the names of places, in which the Danish language, though dead elsewhere in England, still lives. Problems of this kind can be worked wherever we have a map to work with.

20. Now let us transport ourselves to some museum. We see in it nice specimens of workmanship from the South Sea Islands—adzes, for instance, made of flint, metal being unknown. These are quite recent; they were used less than six years ago. But what do we find in a museum of another kind, a museum of antiquities? Why, just the same stone adze from the neighbourhood of London, Edinburgh, or Dublin. But these are, perhaps, two thousand years old, and have been dug

out of the old burial-places of our earliest ancestors, ancestors who lived so long ago as not to have known the use of metals, but to have worked with stone implements only like the present South Sea Islanders.

21. What has thus been written serves to indicate the way in which the varieties, the migrations, and the early history of the civilization of the human species, may be observed. —ROBERT GORDON LATHAM.

Natural History.

BY ROBERT PATTERSON.

LESSON I.

THE INSTINCTS OF ANIMALS.

"To see how God in all his creatures works."
SHAKSPEARE.

"Birds and beasts,
And the mute fish that glances in the stream,
And harmless reptile coiling in the sun,
And gorgeous insect hovering in the air,
The fowl domestic, and the household dog."
WORDSWORTH.

1. THE first time I ever saw a lark's nest it was pointed out to me in a pasture-field, by a tall, vigorous old man with silvery hair. He was a labourer in the fields and little gardens attached to the cottage where we lived during the summer months. The sight of this nest, and of the lark high up, as it seemed to my eyes, among the fleecy clouds of a summer sky, was one of those little events of childhood which are looked back upon with pleasure amid the business and anxieties of maturer years. Perhaps I remember it the more because the old man used occasionally to lay down his spade or his scythe, place me on his knee, and repeat, to my great delight, passages from the poems of Robert Burns. Thus it has happened that the speckled breast of the lark has, in my mind, been ever associated with green fields, blue skies, and melodious numbers.

2. It was about this time I first began to notice the

proceedings of the swallow: a pair had built their nest in our hay-loft; where covered up in the hay, it was my custom to lie for the purpose of watching their fond endearments and their ceaseless tending of the young brood, or to listen to the sweet and loving notes that evinced their happiness. Time rolled on, and I began to inquire why it was that the lark built her nest on the ground, when she might, like the swallow, have avoided so exposed a situation, and have given her callow young the shelter afforded by the hay-loft? And coupled with this was another question, why did the swallow leave us in the autumn to return in the spring, while the lark remained with us throughout the year? The answers were by no means satisfactory. Some persons candidly said they did not know; others met the difficulty by asserting that it was owing to the different *instincts* of the two birds. Soon this word *instinct* became a puzzle to me. I did not understand what it meant; but my seniors used the term as if it opened the portals of knowledge, and gave access to its hidden treasures with a power like that of the "open sessame" of the Arabian tale. It seemed to explain to them the varied actions of the inferior animals. The evening flight of the bat, the noon-day labours of the bee, the morning carol of the lark, were all referred to *instinct*.

3. The common but incorrect idea, that the actions of the lower animals are to be attributed solely to instinct, and those of man to reason, will be referred to hereafter. At present the point to be ascertained is, "what is the meaning of the term instinct?" and years passed by before I was aware of the very different opinions expressed by eminent writers on the question. One author has contended that animals are mere machines; others have maintained that all their actions are the result of observation, invention, and experience; while by others they are regarded as arising from an immediate and constant impulse of the Deity. Such discussions would here be out of place. But although it is not expedient to venture into disquisitions respect-

ing the nature or essence of instinct, we may advantageously inquire what meaning is attached to the word by some of the best-known writers on the subject.

4. Paley says, "An instinct is a propensity prior to experience, and independent of instruction. We contend that it is by instinct that animals cherish their offspring; that the young quadruped is directed to the teat of its dam; that birds build their nests and brood with so much patience upon their eggs; that insects which do not sit upon their eggs deposit them in those particular situations in which the young when hatched find their appropriate food; that it is instinct which carries the salmon, and some other fish, out of the sea into rivers, for the purpose of shedding their spawn in fresh water."

5. In Kirby and Spence's 'Introduction to Entomology' there is a chapter on the instinct of insects, one of the few subjects on which the learned and amiable authors entertained a difference of opinion. Mr. Spence, in speaking of instinct, expresses himself thus:—"Without pretending to give a logical definition of it which, while we are ignorant of the essence of reason, is impossible, we may call the instincts of animals those unknown faculties implanted in their constitution by the Creator, by which, independent of instruction, observation, or experience, and without a knowledge of the end in view, they are impelled to the performance of certain actions tending to the wellbeing of the individual and preservation of the species; and with this description, which is in fact merely a confession of ignorance, we must, in the present state of metaphysical science, content ourselves."

6. More than the third part of a century has passed since those lines were written, and the state of ignorance there mentioned remains unchanged. Naturalists have during that period explored foreign countries, observed the habits of their various tribes of animals, and gained a better knowledge of those inhabiting seas and rivers. Men of science have, by laborious research, conducted

with the aid of improved apparatus and instruments, revealed much that was before unknown in the structure of the animal frame, and the functions of its several parts; mental philosophers have successfully pursued their investigations in the wide field of psychological science: but no one has yet arisen to combine the stores of knowledge accumulated by the zoologist, the physiologist, and psychologist, and to elaborate for our instruction a satisfactory and philosophical treatise on instinct.

7. A little reflection shows very plainly what is the nature of the difficulty that besets questions respecting the nature of instinct. In acquiring a knowledge of the physical universe, we employ our senses, and reason upon the facts which they make known. In pursuing our investigations of the mental constitution of man, we have the advantage and guidance of our own consciousness. But in inquiries into the mind of the inferior animals, neither of these modes of arriving at truth is available, and we are obliged to infer from their actions what is the nature of that mental impulse from which those actions originate. There was reason, therefore, for the remark of Bonnet, that we could never know what instinct was until we had passed some time in the head of an animal.

8. But although we cannot demonstrate the accuracy of our conclusion, as we can in physical or mathematical science, we may still pursue our inquiries with advantage arising from the present state of knowledge in collateral departments; and may accumulate facts showing the circumstances under which instinct in its humblest manifestations is observed, and trace the evidence of its existence in creatures of higher organization, until we see it united with some degree of intelligence if not of reason.

9. In the lowest grades of animal life are creatures, destitute of all those organs and senses, usually considered essential to animated beings. A little higher in the scale, the physiologist is able to point out, in a

simple and rudimentary form, a nervous system, and to observe the performance of some instinctive actions. Advancing to a higher structure he shows a more developed nervous system, and instincts of a higher and more varied order, until faculties of a different kind seem associated with them. The store of facts which the physiologist thus collects is of great value in throwing light on the "palpable obscure" of animal instinct.

10. It is hoped that a work founded on the combined and extended researches of scientific men, in the different regions of inquiry, may ere long be supplied. Such an addition to our literature would be of great and abiding value. But meanwhile the humble inquirer after truth can do little more than systematize the facts which his assiduity may collect.

11. Without venturing, therefore, to speculate on the nature or essence of instinct, I shall employ the term in a sense somewhat similar to that in which it is used by Paley and by Spence, in the passages already quoted, and classify under different heads some of its most striking manifestations. These furnish, when properly authenticated, the only sure foundation for rising to the philosophy of the mind of animals as revealed by their actions; and they are in a high degree interesting, as relating to what the poet calls "our fellow-mortals,"—the joint occupants with us of this fair and fertile earth, and joint partakers of the superintending Providence by whose fiat they were created.

12. Different classes of actions may be looked on as emanating from instincts, but all may be arranged under two general heads:—1st, Those for the production and support of offspring; and 2ndly, Those for the welldoing of the individual.

LESSON II.

INSTINCTS FOR THE PRODUCTION AND SUPPORT OF OFFSPRING.

"The stork in the heavens knoweth her appointed time, and the turtle, and the crane, and the swallow, observe the time of their coming."

1. In the description of spring given by the poet Thomson, he refers to the change that takes place in the plumage of birds prior to their pairing; and in graphic and harmonious lines he enumerates some of the "coy quiristers," and the various situations from which their several notes are heard, and adds—

> "'Tis love creates their melody, and all
> This waste of music is the voice of love;
> That even to birds and beasts the tender arts
> Of pleasing teaches."

The instinct, universally diffused, which prompts to the union of the sexes, is thus brought before us in one great class of the animal kingdom. It is unnecessary to attempt to trace its manifestations throughout the other classes, and the diversified and wondrous modes by which the Divine command to "increase and multiply" is accomplished: such topics would be unsuited to the scope and objects of the present treatise. But there are others intimately connected with these, and relating to journeys undertaken, labours accomplished, and dangers encountered, apparently for the production and sustenance of the young, which may briefly be adverted to. The first of these is *migration*, which is observed to take place in certain species of each of the classes of vertebrate animals, as well as among some of the inferior tribes. In the mammalia it is known among the bisons of America and the antelopes of Africa, and is generally attributed to the desire among these vast herds to seek out fresh pastures, or to avoid some physical inconvenience. Such migrations are periodical, and are accomplished with so much regularity, that the hunter of these animals makes his arrangements with as much confidence as he would have in the recurrence of any of the phenomena dependent on the seasons. But there are some migrations amongst quadrupeds which take place at uncertain intervals, and cannot be accounted for on the same supposition—perhaps it would be more correct to say that they cannot be satisfactorily explained on any hypothesis which has yet been brought forward. A striking example of this is furnished by the lemming, (fig. 1) a creature belonging to the group which includes the rat and the mouse. It is a native of the mountainous parts of Norway and Lapland, from which at uncertain periods it descends in immense troops.

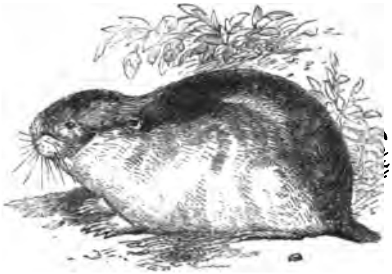


Fig. 1.

2. But when in these countries we speak of migratory instincts, we involuntarily turn to the feathered tribes, as furnishing the best and most familiar examples: we call to mind the joyous note of the cuckoo, the graceful sweep of the swallow, and the pleasure with which we observe the arrival of other species, the heralds of spring, or the "guests of summer." Our thoughts then wander to the opposite season of the year, and we think of birds which leave the Arctic seas, and come in regular array, oft-times with clanging notes, to give life and animation to the marsh, the mountain tarn, the estuaries of our rivers, and the winding shores of our bays. When the naturalist enumerates the species which have flown from the sunny regions of the South, and made these countries the limit of their northern range; when he reckons those which have arrived from Arctic climes, these islands being the boundary of their descent southward, and then tries to estimate, however imperfectly, the number

of individual birds thus sent over a portion of the earth, with marvellous regularity, and obviously for the most beneficent purpose, he needs not to ask himself the question,—"Who forms the phalanx, and who points the way?" He sees in all this regularity the guidance of a Divine hand.

3. We must not, however, found our estimate of the mighty movements attendant on the migratory instinct on anything that can be observed here; let us turn to the Mediterranean, the Archipelago, and the shores of Africa, and endeavour to realize the idea of the immense flocks of quails (fig. 2) by which these localities are visited. Such prodigious numbers appear on the western coasts of the kingdom of Naples, that a hundred thousand have in one day been caught within the space of three or four miles. Or let us direct our attention to North America, and hearken to the details of the passenger-pigeon given by Wilson, Audubon, and other credible witnesses. So great are the numbers of these birds that they darken the air, that trees and herbage are destroyed where they settle. Attempts to compute the multitude in those vast flocks have been made, and give results which we can express in figures, but of which our mind can in reality form no conception.

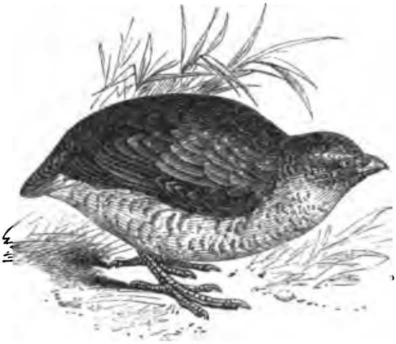


Fig. 2.

4. The migratory instinct in fishes is not less remarkable than in birds. By it the species which at other times are habitually the inhabitants of deep water, approach the shores for the purpose of depositing their spawn.

By it the salmon (fig. 3) and other fishes are impelled to forsake the sea, and push their way up rivers in defiance of numerous obstacles, that the precious spawn by which the race is perpetuated, may be placed where circumstances are favourable to its development. Our knowledge of the process instinctively performed by these fish is now enabling us to stock our rivers with them, and by so doing to increase the abundance, and consequently the cheapness of an important article of food. This is but one of the many instances in which a knowledge of the natural processes which are going on around us may lead to results which were never anticipated by the mere utilitarian.

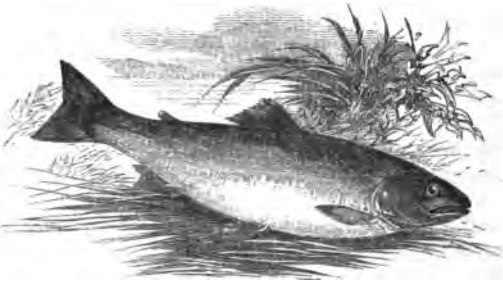


Fig. 3.

5. Among the reptile tribes we have similar examples in connection with the deposition of their eggs. Marine turtles in vast multitudes come for this purpose to the Gulf of Florida, the island of Ascension, and other localities. The eggs are laid in a hole scraped on the beach, and covered with sand; and this great object having been accomplished, the female makes good her retreat to the water. Analogous to this proceeding, but suited to the different circumstances of the agent, is the migration performed by land-crabs for the same purpose.

6. Different orders of insects supply examples of the migratory instinct, though the cause and the object of the migration are not always apparent. The husband-

man in several parts of these kingdoms, knows but too well the myriads in which the aphides or plant-lice occasionally appear, accompanied by other insects that prey upon them.

The locusts (fig. 4), however, furnish the best-known and most striking example of migratory swarms. In the East their appearance and their powers have been often described, but never with such graphic and terrible effect as by the prophet Joel. In the West they also occur: Darwin has in his 'Journal' recorded the occurrence of a swarm, near Luxan, province of Mendoza, and given a very vivid idea of their numbers. "When," says he, "they alighted they were more numerous than the leaves of the field, and the surface became reddish instead of being green."

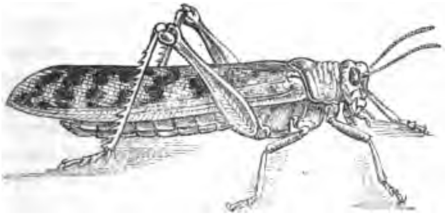


Fig. 4.

7. But while the existence of the migratory instinct is an admitted fact, and while we are able to connect it in some instances with the depositions of eggs, there are others to which such explanation will not apply. Nay, in regard to some where at first sight it may seem applicable, it will not on a more careful scrutiny be altogether satisfactory. The male and female salmon, after the eggs are deposited, soon return to the sea. The young escape from the ova, and, after attaining a certain stage of growth, they also forsake their native river for the sea. They do so by a purely instinctive impulse. They have had no teaching and no experience; yet they all invariably adopt the same procedure. Their return *to* the river is succeeded by the deposition of ova, but the

original movement *from* the river cannot thus be accounted for. It is the result of a purely migratory instinct.

8. The male cuckoos arrive in these countries in April; the females follow: the eggs are in due time produced, and, in accordance with the strange instinctive habit of the female, are dropped into the nests of the hedge warbler, the meadow pipit, and other small birds. The parents leave the country in June, or early in July. The young cuckoo has not then acquired the use of its wings. It has had no intercourse with its parents, and consequently no teaching from them. Its foster parents do not migrate. Yet when September comes, it leaves the place of its nativity, and makes its way to the same countries which the adult birds frequent. If confined at that time, it will break its wing-feathers against the bars of the cage by its efforts to escape and fly. Here, also, we must own, that the first, the original flight, is an impulse not directly connected with the propagation of the species; but instrumental in promoting the wellbeing of the individual, by directing it to a country, furnishing both the needful food and the required temperature.

9. There are numerous instances on record, where the migratory instinct is so potent as to overcome even the ardent feelings of parental attachment. Many nests of the house martin and of the swallow are annually deserted, and the young nestlings of the late broods left to perish, while the parents, under the mysterious promptings of the migratory instinct, wing their way to other climes.

10. The next instinct to which I shall allude, in connection with the propagation and support of the young, is that of *nest-building.*

Every schoolboy knows the great diversity exhibited by our native birds, both as regards the situation of the nest and the materials of which it is constructed. The rocky platform and the shingly beach; the lofty tree-top, and the lowly bush; the projecting eaves of our dwellings; the greensward of our pastures—furnish to different species of birds the most suitable localities for their nests, and for the display of those varied powers required for their different mode of building. If we turn our attention to foreign climes, we have additional examples of the "Architecture of Birds" in the substantial roof of the sociable grosbeak, the woven pensile nest of the baya (fig. 5), the leaves stitched together by the tailor-bird, and the gelatinous nest sought for in Java, amid the gloom and perils of sea-caves, to minister to the enjoyments of the Chinese epicure. But the instinct of nest-building must not in the present instance be restricted to birds; it shows itself wherever a nest or dwelling is formed, whether employed or not for the convenience, the comfort, or the safety of the future young. In this sense it is displayed by several quadrupeds, and reaches its highest development in the mansions of the beaver (fig. 6), structures so wonderful that they have given rise to a tradition current

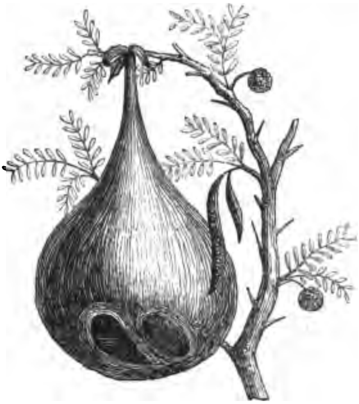


Fig. 5.

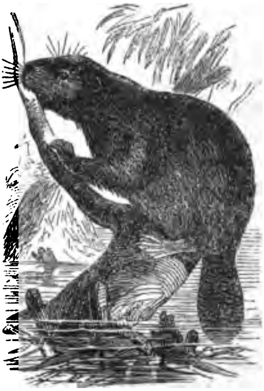


Fig. 6.

among some of the American Indians, that the beavers are a fallen race of human beings, who in consequence of their wickedness vexed the Good Spirit, and were condemned by him to their present shape, but that in due time they will be restored to their humanity.

11. The same instinct displays itself among fishes. In general the ova when deposited, cease to be objects of solicitude. But to this, so long ago as the time of Aristotle, one exception was known. Another is related by Dr. Hancock of a fish called the hassan, at Demerara. Professor Agassiz communicated to the American Association for Science his own observations on a couple of cat-fish, engaged in the care of their nest and young on the shore of Lake Labago. Mr. Couch made known some years ago the existence of similar habits in the fifteen-spined stickle-back of our own coasts; and more recent observations, by Mr. Albany Hancock, have shown that the little stickle-back of our streamlets is not behind any of its brethren, either in the formation of a nest or in watchful superintendence of its young.

12. Among insects we have examples of nest-building of two distinct and characteristic kinds. One is the excavation of a nest in wood or in clay, designed specially for the reception of the eggs, and of the food necessary for the sustenance of the future young. The other is the formation of those populous structures, which form not only the nurseries of the young, but the residence of their nurses, and all other members of the community. The first is exhibited by the solitary wasps and bees, the latter by the social tribes belonging to the same order. Those insects have in all ages attracted attention, and the account given of their labours by competent observers in different countries, furnishes another instance of truth being "stranger than fiction."

13. *Oviposition.*—From the instinct which prompts the building of the nest, we naturally turn to that which relates to the laying of the eggs, and some examples of this have incidentally been mentioned. The subject is one in the highest degree interesting,

as with it is involved the continuance of many tribes of animals. Were it possible here to examine some of the variations from the ordinary course of procedure, they would serve to show the wisdom by which both the rule and the exceptions are regulated.

14. Among some insects, the deposition of the egg on a leaf or stem produces an excrescence, which forms the habitation of the young. In one numerous tribe, the Ichneumons, the parent insect pierces the body of a living caterpillar, places therein the egg of a grub, which is to prey upon that caterpillar, and destroy it. Sometimes, not one egg but many are deposited in this strange receptacle, according to the habits of the different species, and the amount of food required for the embryo young. Not less singular are the proceedings of the bot-fly, a parasite of the horse. The eggs are deposited by the parent on those parts of the body which the horse is most apt to lick, and on those parts only. The eggs are thus taken into the stomach, and there remain until the enclosed grubs have attained their full size as "bots."

15. *Incubation.*— This instinct manifests itself in ways so striking, that it rouses our attention, and fixes our sympathies on the parent birds. That a free tenant of the air should voluntarily become a prisoner, bound to one spot, and never moving from it, save from the most imperative necessity, is indeed one of those wonders with which nature abounds, and which lead us reverently to see the goodness of the Almighty Author. As the time for the hatching of the eggs draws to a close, the attraction of the hen bird to the nest continues to increase, until she will allow herself to be pushed by the hand, rather than leave it. From this, we may probably explain how it is that the rail continues on her nest, despite of the approaching scythe of the mower, at the risk and sometimes with the loss of her life. Mr. Broderip mentions a curious circumstance: the egg of a condor was placed under a hen at the Zoological Gardens. After an incubation of

fifty-four days, the young bird was produced. "In this case," says Mr. B., "I was struck with the modifications of instinct, or rather of the adjunct of something closely resembling a reasoning power on the part of the hen. In general, as soon as the days of her incubation are fulfilled, the hen leaves the nest, if the eggs are addled, or have not been hatched from some other cause. But here she continued to sit, more than double the usual time, without moving, except for the purpose of taking food."

16. The *nourishment* of the young calls forth the most active power of the parent to procure the necessary food.

Among birds we find incessant activity; whether the food be seed or insects, fishes, birds, or small quadrupeds, whatever is required is abundantly supplied. In cases where the young animals are helpless at birth, the instinct of the parents amply compensate for their inability to help themselves. Among some of the lower animals, the egg is placed where the food required by the grub is at hand. Thus the butterfly places her eggs on a leaf on which the caterpillar is to feed, while she herself takes only a few drops of honey; and the mason and carpenter wasps, furnish a supply of food to each cell where an egg is deposited. This habit of storing food for the young seems to extend in some cases to the higher animals. Professor Bell, in speaking of the polecat, quotes the words of a writer in Loudon's Magazine, who found five young polecats in a nest; but in a side-hole, says the narrator, "I picked out and counted most carefully, forty large frogs and two toads. They were all alive, but merely so; capable of sprawling a little, and that was all, for the mother had contrived to strike them all with palsy. They were merely capable of sprawling, and not of moving away; and on examination I found that the whole number, toads and all, were bitten through the brain."

17. It occasionally happens that the parents continue their vigilant care of the young, under circumstances

the most opposite to their usual habits. Dr. Martin Barry stated in a paper read before the British Association for Science, 1852, that in Germany a pair of the black redstart (*Sylvia tithys*) had built their nest at Giessen, in the collision spring of a third-class railway carriage, which had remained for some time out of use. The waggon-master, humanely desired his men to avoid as long as possible running the carriage. At length, when it could no longer be dispensed with, the carriage was attached to a train. At the end of four days and three nights, during which time it had been thirty-six hours at Frankfort and had also been at Giessen and Lollar, the nest was found not to have been abandoned by the parent birds, and to contain young ones. It was then removed to a secure place of rest, and remained there till the five young birds had flown.

If to the instincts now enumerated, namely that of migration, nest-building, oviposition, incubation, and nurture of the young, is added that which prompts to their protection, whether by courage to repel danger, or by stratagems to lead the intruder away, we shall have before us a wonderful amount of provision for the production, the sustenance, and the safety of those who are too feeble to help themselves.

LESSON III.

INSTINCTS FOR THE WELLBEING OF THE INDIVIDUAL.

> "What call'st thou solitude? Is not the earth
> With various living creatures, and the air
> Replenish'd, and all these at thy command
> To come and play before thee? Know'st thou not
> Their language and their ways? They also know,
> And reason not contemptibly."
>
> MILTON.

1. THE first of the instincts comprised under this head relates to the means of escape from enemies: and this manifests itself in two ways, by flight and by concealment.

The former is the more general and more obvious; and to the energies which it calls forth, the sportsman owes the pleasures of the chase, those pleasures which seem common to man in all stages of civilization. In the second, when the colours of the animal are such as to give it a likelihood of escape, because of the similarity of its tint to that of the surrounding objects, quietude is preferred to exertion. Insects will remain motionless on a ground similar to their own tints; small flat-fish will lie close upon the sand or mud; the ptarmigan will cower among the lichens; and the cuttle-fish, which has more than one means of escape, will prefer in the first instance that which is supplied by its change of colour. In speaking of these creatures Mr. Darwin says, "This cuttle-fish displayed its chameleon-like power, both during the act of swimming and whilst remaining stationary at the bottom. I was much amused by the various arts to escape detection used by one individual which seemed fully aware that I was watching it. Remaining for a time motionless, it would then stealthily advance an inch or two like a cat after a mouse, sometimes changing its colour: it thus proceeded, till having gained a deeper part it darted away, leaving a dusky train of ink to hide the hole into which it had crawled." Many of the inferior animals, such as the sea-anemones, and lesser zoophytes, the vorticellæ, &c., avoid danger simply by withdrawing their tentacula or contracting their bodies.

2. Next in order may be mentioned the instinct for the procuring of food: wherever animal life exists this must of course be present. The whale of the Arctic seas, the elephant of the African plains, the tiger of the Indian jungle, all manifest its influence. Not only does it indicate to each animal its appointed food, but also the mode by which it is to be procured. The carnivora are guided to the parts of the body where the attack may prove most immediately fatal, as the throat of a large quadruped, or the head of a small one, where the skull can be easily pierced. The puma, or South American lion (fig. 7), kills its prey by springing on the

shoulders, and then drawing back the head with one of its paws, until the vertebræ break. Mr. Darwin says he has seen in Patagonia the skeletons of guanacos (wild llamas) with their necks thus dislocated. The Echidna of New South Wales, like the ant-eaters, subsist on ants, and other small insects: these are procured by means of the long slender tongue, which is covered with a viscid secretion.

Fig. 7.

3. The fishing-frog displays its tempting hues, and waits to snatch the unwary fish that may come within its reach ; and the ant-lion excavates its conical pit, and, concealed at the bottom, lies in wait for its victim. Force in some cases, stratagem in others, procures the necessary food. Occasionally the food is of a kind which we would not have ventured to imagine. Such is the fact of the rein-deer feeding on a lichen, or the *amblyrhynchus*, a lizard belonging to the Galapagos archipelago, upon sea-weed, which grows at the bottom of the sea, and can, therefore, only be reached by swimming under water. But imagination fails to invent combinations or arrangements so strange as those revealed by the patient observation of the naturalist. Who would venture to suppose that there is a crab at Keeling Island which lives on cocoa-nuts?—and yet we have the testimony of Darwin to the fact :—

" I have before alluded to a crab which lives on the cocoa-nuts: it is very common on all parts of the dry land, and grows to a monstrous size: it is closely allied or identical with the *Birgos latro*. The front pair of legs terminate in very strong and heavy pincers, and the last pair are fitted with others weaker and much narrower. It would at first be thought quite impossible for a crab to open a strong cocoa-nut covered with the husk; but Mr. Lusk assures me that he has repeatedly seen this effected. The crab begins by tearing the husk, fibre by fibre, and always from that end under which the three eye-holes are situated: when this is completed, the crab commences hammering with its heavy claws on one of the eye-holes till an opening is made. Then, turning round its body, by the aid of its posterior and narrow pair of pincers, it extracts the white albuminous substance. I think this is as curious a case of instinct as ever I heard of, and likewise of adaptation in structure between two objects apparently so remote from each other in the scheme of nature, as a crab and a cocoa-nut tree."

4. *Habitation.*—Shakspeare has said of the snail, "He carries his house on his head." The same might be said of the hermit-crab, although the "house" is not fabricated by himself, but by one of the *mollusca,* who has probably died and left his dwelling to the crustacean. Those who have watched the hermit-crab when in search of a house describe him as a very fastidious gentleman, hard to please, and testing very carefully whether or not it will suit him.

5. But when speaking of the instinct which prompts animals to construct dwellings, it is not to such as these that I wish to refer, but to others fabricated by labour of some kind for the purpose of a habitation. The tube of the *terebella* (fig. 8), formed of particles of sand and shells agglutinated together, is an example of a rude and simple dwelling-house at one end of the scale—the skilful and elaborate structures of the beaver stand at the other.

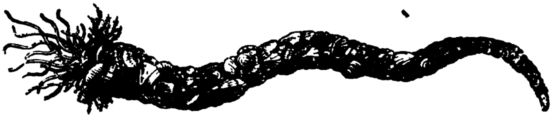


Fig. 8.

The amount of labour which animals voluntarily undergo is, in some instances, very surprising. Thus, the water-mole (*ornithorhyncus*) (fig. 9) of New South Wales, will make a burrow to its nest extending from the bank of the river a distance of twenty, thirty, or even fifty feet. Not less extraordinary are the tubes formed by the trap-door spiders (fig. 10.) Some of these are only from four to six inches in length, but in others they are as much as two feet. The walls for their entire length are covered over with a silken web, and at the outer extremity of the tube is a door accurately fitted to the orifice, and hinged with the greatest care, so as to be opened and shut with ease.

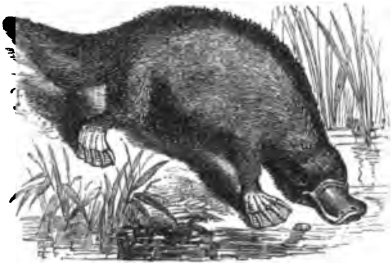


Fig. 9.

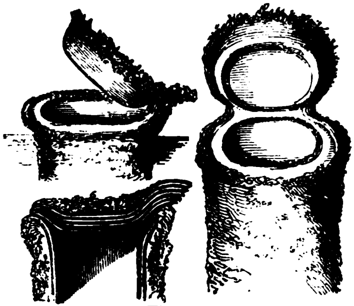


Fig. 10.

6. It is, however, among those insects that live together in populous communities, that the mansions, the storehouses, and the nurseries, present us with examples of the building-instinct in its highest development. Examples of this might be furnished by the hive-bee, and by different species of ants; but as one example must suffice, let us take that of the white ant (*Termes bellicosus*), a species common on the African coasts. The nests are formed of clay, are generally twelve

feet high, and proportionally broad, so that a cluster of them might be mistaken for a village. They are substantial as well as capacious, so much so that Mr. Smeathman, with four others, has stood on the top of one of these hillocks to look out for a vessel. He minutely describes what he calls the royal apartments, the nurseries, the magazines, the passages, galleries, and bridges, used for internal communication, and the subterranean roads or tunnels for intercourse with the world without. So vast are these structures compared with the size of the architects, that they far exceed in this respect the boasted works of man.

7. *The instinct for society.*—The social instincts pervade very extensively the different classes of the animal kingdom. The term *gregarious*, which we apply to our flocks and herds, to some quadrupeds in a wild state, to rooks and some other birds, implies that they all act in conformity with this impulse. In other tribes its existence is periodical not permanent, as in some of those mentioned under the head of "Migration."

The habits of many of our most common native birds, as described by the poet, offer examples of the working of the social propensity :—

> "More obviously, the self-same influence rules
> The feathered kinds; the fieldfares pensive flock;
> The cawing rooks and seamews from afar,
> Hovering above these inland solitudes,
> By the rough wind unscattered, at whose call
> Up through the trenches of the long-drawn vales
> Their voyage was begun: nor is its power,
> Unfelt among the sedentary fowl
> That seek yon pool, and there prolong their stay
> In silent congress: or together roused
> Take flight, while with their clang the air resounds."
> WORDSWORTH.

Among many families of insects its influence is noticed, under circumstances where no joint labour of any kind like that of bees or ants requires the association, and where it can be accounted for only by the influence of this principle.

" What other spirit can it be that prompts
The gilded summer flies to mix and weave
Their sports together in the solar beam,
Or in the gloom of twilight hum their joy?"

8. *Hybernation.*—If certain animals in these countries became torpid at the approach of winter, and renewed their activity at the return of spring, we might suppose that they were acted on merely by the physical agency of heat or cold, and need not attribute to them any instinct prompting them to prepare for the winter sleep. But we find that many of the hybernating animals make ready their winter retreat, or lay up their store of provision, while the weather is yet fine, and the cold season remote. " I am led to believe from my own observation," says Mr. Spence, in the Introduction to Entomology, " that the days which the majority of Coleopterous insects select for retiring to their hybernacula (or winter quarters) are some of the warmest days of autumn." Among animals inhabiting Britain, the squirrel and the dormouse, by their prudent foresight in storing up nuts, acorns, and other fruits, remind us of the ant described by Solomon, " which provideth her meat in the summer, and gathereth her food in the harvest."

9. Perhaps no creature lays up a more abundant store of provender than the rat-hare, described, by Professor Pallas, as living among the mountains of Siberia, sometimes in solitude and sometimes in small societies, according to the nature of the mountains they inhabit. " About the middle of the month of August these little animals collect with admirable precaution their winter's provender, which is formed of select herbs, which they bring near their habitation, and spread out to dry like hay. In September they form heaps or stacks of the fodder they have collected under the rocks, or in other places sheltered from the rain or snow. Where many of them have laboured together, their stacks are sometimes as high as a man, and more than eight feet in diameter. A subterranean gallery leads from the burrow, below the mass of hay, so that neither frost nor snow can intercept their communication with it."

These stacks of excellent forage are sought out by the sable-hunters to feed their harassed horses; and the natives of that part of Siberia make use of them, for the subsistence of their cattle."

10. The different instincts now enumerated are *original*, or implanted in the animals from their creation. But there are others which are *acquired*, yet which in a generation or two become hereditary.

Many examples of this curious fact occur in the different races of the domestic dog, and are too well authenticated to admit of any question. The indifference evinced towards man by birds in islands which he visits for the first time, or where his presence is of rare occurrence, becomes changed after experience of his power into fear; and this fear of man becomes an hereditary instinct with the young birds, just as it is with those which are natives of these countries.

11. To Mr. Spence we are indebted for first bringing prominently forward the great number of instincts with which some animals are endowed. In this respect the bee and the ant much excel creatures of larger dimensions. After enumerating many of the instincts brought into action in the ordinary range of duties performed by the working-bee, not including those exhibited by the queen, the drones, or the wax-makers, he remarks—"I have now instanced at least thirty distinct instincts with which every individual of the nurses amongst the working-bees is endowed; and if to the account be added their care to carry from the hive the dead bodies of any of the community; their pertinacity in their battles in directing their sting at those parts only of the bodies of their adversaries which are penetrable by it; their annual autumnal murder of the drones, &c., it is certain that this number might be very considerably increased, perhaps doubled." The hive-bee furnishes us with a striking instance of the remarkable fact that an instinct may remain quiescent for successive generations, and may then, when the necessity for it comes, be suddenly developed or roused into activity. Under

ordinary circumstances the hive is always supplied with a queen, and other queens are developed which lead forth the swarms when the population becomes excessive. But if by some occurrence the hive is suddenly deprived of its queen, the bees select one or more of the young worker brood to be educated as queens. These being placed in royal cells, and fed with royal jelly, come forth complete queens, with their forms, instincts, and powers of generation entirely different from those they would have possessed had they continued in the cells they originally inhabited.

12. There are instances well authenticated of animals finding their way home under circumstances that seem to us very inexplicable.

One of these is mentioned by Mr. Spence. It relates to an ass shipped from Gibraltar, and thrown overboard in a storm at the Point de Gat. The animal, after swimming ashore, made its way a distance of two hundred miles across a mountainous and intricate country where it had never been before, and in a few days presented itself for admission to the fortress, when the gates were opened in the morning. The possession of reason would not have enabled the animal to achieve this feat. Can it be referred to anything instinctive? or should we adopt Dr. Alison's idea, that "the only term properly applicable to the acquisition of this knowledge is *intuition?*"

LESSON IV.

ACQUIRED INSTINCTS AND REASONING OF ANIMALS.

1. **Perhaps** this is the proper place to remark that many animals possess senses greatly superior in delicacy or in acuteness to those of man; and in some the power of exercising them is not dependent on experience as in man, but is enjoyed from birth. This superiority does not, however, appear to be accompanied by any appre-

ciation of the beauty so bountifully diffused over the physical creation. To man alone does the fair face of the external world present itself under the guise described by the poet:—

> " Earth, in her rich attire,
> Consummate lovely, smiled."

2. Dr. Darwin, in his 'Zoonomia,' mentions a remarkable example of something like reasoning in animals. Walking one day in his garden, he perceived a wasp on the gravel walk, with a large fly nearly as big as itself, which it had caught. Kneeling down he distinctly saw it cut off the head and abdomen, and then taking up with its feet the trunk, or middle portion of the body to which the wings remained attached, fly away. But a breeze of wind acting on the wings of the fly turned round the wasp with its burthen, and impeded its progress. Upon this it alighted again upon the gravel walk, deliberately sawed off one wing and then the other, and, having thus removed the cause of its embarrassment, flew off with its booty.

3. Not only do animals in many instances evince an adaptation of means to accomplish a certain end, but oftentimes they modify their habits and modes of life, in accordance to the circumstances in which they are placed. Thus, we learn from Darwin's 'Journal,' that where the Bizcacha, an animal resembling a large rabbit, and common on the Pampas of South America, lives and makes its burrows, the Agouti, an animal representing our hare, uses them; but where, as at Bahia Blanca, the Bizcacha is not found, the Agouti burrows for itself. "The same thing occurs with the little owl of the Pampas, which has so often been described as standing like a sentinel at the mouth of the burrows; for in Banda Oriental, owing to the absence of the Bizcacha, it is obliged to hollow out its own habitation."

4. A similar circumstance has been observed of the common hare in Erris, a sandy district in the county Mayo, in the west of Ireland, exposed to the storms of the Atlantic. Instead of remaining content with a

"form," as elsewhere, poor puss is compelled to excavate a burrow, and makes it with two entrances, so that, when threatened with danger by the shifting sands, she commands a mode of escape. But among animals, we have instances not only of a conformity to circumstances, and an adaptation of means to an end, indicative of a power of reasoning, limited in extent, yet analogous to that exercised by man, but we notice in their actions the outward indications of emotions and passions similar to those by which he is actuated. We see the strongest manifestations of love and anger, of fear and triumph, of joy and of sorrow, &c.; so that there is here a wide range of mental phenomena, to some extent common to man and to the inferior animals. This may be best proved by some well-authenticated examples.

5. The wish to be caressed, or desire of approval, was evinced very decidedly at the Zoological Gardens, in London, by a she-wolf, "which," says Professor Bell, "would always come to the front bars of her den to be caressed, as soon as I, or any other person whom she knew, approached: she had pups, too; and used to bring them in her mouth to be also noticed; and so eager, in fact, was she that her little ones should share with her in the notice of her friends, that she killed all of them in succession by rubbing them against the bars of her den, as she brought them forward to be fondled." Animals appear at times very conscious of their misconduct. Mr. W. Thompson, in his 'Natural History of Ireland,' relates that a sea-eagle killed four pet birds, his constant companions in the same enclosure, and mentions that "the eagle had partly plucked the falcon preparatory to eating it, just as his master appeared in view, when he instantly sprang from the body of his victim, and further evinced the consciousness of his misdeed, by allowing it to be carried off, though any food given in the ordinary manner, he would not permit to be removed."

6. Perhaps, however, an anecdote, which I give on the authority of my valued friend, Dr. Ball, the indefatiga-

ble Secretary of the Royal Zoological Society of Ireland, will serve better than anything else to exemplify the mingled motives, or feelings, by which some of the brute creation are occasionally actuated.

A few years since a large chacma baboon (fig. 11) was presented to the Royal Zoological Society of Dublin: he was an ugly, surly, unhealthy beast. Placed in an open cage, he recovered health and strength, and became ferocious, and not unfrequently tore the clothes of persons who incautiously approached him. The Secretary of the Society constantly visited him, and experimented on his disposition by speaking to and looking kindly at him: the chacma appreciated this probably rare conduct towards him, and manifested such kindliness of feeling in return, that this gentleman soon intrusted his hand to him, and shortly after his head. The chacma appeared delighted at being permitted to arrange his friend's hair. Dr. B. studiously avoided giving the animal apples, nuts, &c., desiring that his influence should be solely derived from kindness of deportment. At this time it was a source of great amusement to the council and visitors to feign an assault on the Secretary: on such occasions, the rage of chacma was quite beyond description; he screamed loudly, shook his cage with fearful violence, and by his fierce and vengeful looks, directed steadily at the offender, indicated such ferocity that, could he have got out, it is not to be doubted that the life of his enemy would have been lost. So great was his attachment, that he at length became conscious of the time his friend was likely to visit the garden, and for an hour or more before, he

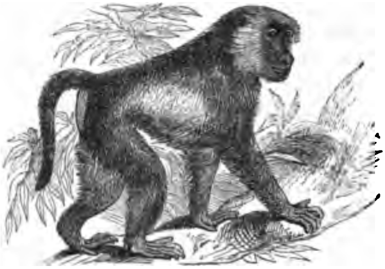


Fig. 11.

would seat himself at the top of his tree on the look-out: from this place it was not easy for a stranger to tempt him down. On the approach of Dr. B. he chattered a little, came down, and shook hands, looking quite happy, always preferring such communion to dainties offered him by others, which he rudely snapped from them.

7. However, it happened one day that a much-lamented member of the society, having some grievance at heart, chose to confide his woes to the Secretary, and took his arm as he entered the garden. The chacma was as usual on the top of his tree, and on approaching the cage he descended; but the Secretary unwilling to interrupt his friend's story, took no notice, and passed several times close before the cage. Chacma seemed to feel hurt at this, and sought to attract attention by calling out loudly. The Secretary thought to himself that poor chacma would be offended, but at the same time did not feel justified in appearing unmindful of his friend. A day or two after, on his approaching the cage, the chacma in the most marked manner turned his back upon him and repeated this procedure on every side of the cage. For several weeks he persevered in this conduct: his face bearing a singularly sullen, but not ferocious aspect. He appeared most anxious, as it were, that he should not seem to see Dr. B., in fact to cut his acquaintance, and looked as if he would not acknowledge his existence. After he had thus continued for some time he took a new course, and the moment the Secretary appeared, he went into his sleeping-place, from whence he must have closely watched, for the instant that gentleman was out of sight he again appeared. After some three months, he ventured to look occasionally at the Secretary, with an unmistakable expression of countenance, which plainly said, "I should be glad to make up the quarrel, but my pride won't let me." Dr. B. offered him the food he liked best, but he would not receive it.

8. On one occasion a lady offered him a flower of laburnum, of which he was particularly fond, and when he reached out his hand for it, she drew the flower back

and gave it to the Secretary. The rage of the chacma, which was solely directed to the lady, was most intense, evidently not at the loss of the laburnum but of its being so disposed of. He would not accept it from Dr. Ball, but after awhile rudely snatched and tore it to pieces. Here we have a quarrel with a friend for an imaginary offence, growing more serious when brooded over—then the feeling manifested of being mistaken, and the desire evinced of a wish to make it up, but the courage wanted to come forward to do so. Could anything have been more like human conduct? It is right to say that, during the whole transaction, the chacma never displayed any desire to injure the Secretary, though his hand was against every other individual, whenever he had opportunity, and he increased in fierceness to the last: his death was probably the result of a blow from some one, whose clothes he had torn.

9. It must be obvious from what has now been advanced, that all the actions of animals must not be referred to instinct, but that many of them must be attributed to emotions and passions similar to those of man; and others can only be explained by conceding to many of the inferior creatures a power of reasoning to a certain limited extent.

"And yet," says Archbishop Whately, "the difference between man and brute, in respect of intelligence, appears plainly to be not a difference in mere *degree*, but in *kind*. An intelligent brute is not like a stupid man. The intelligence and sagacity shown by the elephant, monkey, and dog, are something very different from the lowest and most stupid of human beings. It is a difference in kind, not merely in degree." What then is the difference between the reason of man, and the instinct of animals? or how are actions which are properly the result of reason to be distinguished from those which are instinctive? To this it may be answered:—

10. 1st. That animals do by instinct what no reason could teach them. The young swallow does not by

reason forsake its "pendant bed and procreant cradle," to wing its way to the coast of Africa, nor by reason return with the ensuing spring to the place of its birth. It is not by reason that the common white butterfly makes choice of the cabbage. "Cabbage is no food for her; yet in the cabbage, not by chance, but studiously and electively she lays her eggs." Lord Brougham puts the matter very clearly, thus:—"The *animal* works positively without knowledge and in the dark. She also works without designing anything, and yet she works to a certain defined and important purpose. Lastly, she works to perfection in her way, and yet she works without any teaching or experience. Now, in all this she differs entirely from *man*, who only works well, perhaps at all, after being taught—who works with knowledge of what he is about, and who works intending and meaning, and, in a word, designing to do, what he accomplishes. To all which may be added, though it is perhaps rather the consequence of this difference, than a separate and substantive head of diversity, the animal works always uniformly and alike, and all his kind work alike, whereas no two men work alike, nor any man always, nay any two times alike."

11. 2nd. Animals acting under the impulse of instinct occasionally make mistakes, which reason would have taught them to avoid. Thus the flesh-fly has been known to mistake the blossom of the carrion plant (*Stapelia hirsuta*) for a piece of flesh, and lay her eggs upon it, where the young grubs when disclosed must of course perish for want of food.

"Birds," says White, in his 'Natural History of Selborne,' "in general are wise in their choice of situation; but in this neighbourhood, every summer, is seen a strong proof to the contrary, at a house without eaves, in an exposed district, where some martins build year by year in the corners of the windows. But as the corners of the windows (which face the south-east and south-west) are too shallow, the nests are washed down every hard rain; and yet these birds drudge on to no purpose, from summer to summer without changing their aspect or house."

The martins are not, however, the only birds on which the lessons of experience are thrown away. Darwin, in his Journal, speaks in the following terms of one met with by him in North Patagonia:—"The Casarita builds its nest at the bottom of a cylindrical hole, which is said to extend horizontally to nearly six feet under ground. Several of the country people told me, that when boys they had attempted to dig out the nest, but had hardly ever succeeded in getting to the end of the passage. The bird chooses any low bank of firm sandy soil by the side of a road or stream. Here (at Bahia Blanca) the walls round the houses are built of hardened mud, and I noticed that one, which enclosed a court-yard where I lodged, was bored through by round holes in a score of places. On asking the owner the cause of this, he bitterly complained of the little Casarita, several of which I afterwards observed at work. It is rather curious to find how incapable these birds must be of acquiring any notions of thickness, for although they were constantly flitting over the low wall, they continued vainly to bore through it, thinking it an excellent bank for their nests. I do not doubt that each bird, as often as it came to daylight on the opposite side, was greatly surprised at the marvellous fact."

12. 3rd. Man is distinguished from the inferior animals by the power of forming abstract ideas, and rising to a comprehension of the laws which the Divine Governor of the universe has fixed upon his works:—

> "E'en the poor Indian, whose untutored mind
> Sees God in clouds and hears him in the wind,"

has notions, dim and confused though they may be, of a Creator, to whom all things, both in heaven and on earth, are subject. But we have no indication of any such ideas existing in the minds of animals.

13. In now bringing this article to a close, it seems desirable to sum up the results or conclusions. They may be stated thus:—

1st. That animals (man included) are endowed with a number of distinct impulses or instincts, tending to the welfare of each individual, and to the production, nurture, and protection of their young.

2nd. That the external senses are less perfect in man than in some of the lower animals; and that the latter exercise them in many cases from birth, whilst in man, time and experience are required for their development.

3rd. That some of the lower animals exhibit several emotions and passions similar to those of man, evince a high degree of intelligence, and possess the power of adapting means to a definite end; but man is the only one capable of forming abstract ideas, of reasoning thereon, and of rising to the contemplation or discovery of the great laws of the universe.

4th. That we would not be warranted, in the present state of our knowledge, in attempting to draw a *rigid* line of demarcation between the province of Reason and that of Instinct; we must admit that there yet exists a debatable ground, analogous to the border territory which connects the animal and vegetable kingdoms.—ROBERT PATTERSON.

Political and Domestic Economy.

LESSON I.

MAN INTENDED FOR SOCIETY.

BY JAMES SEWELL WHITE.

"And the Lord God said, It is not good that the man should be alone."

1. EVERY man carries within his own nature incontrovertible proofs that he was destined from the first for social life.

A child comes into the world at first quite unable to do the slightest thing for itself. It has arms and hands, but cannot employ them to any better purpose than to get hold of the nurse's finger when offered within its grasp. It has legs, but cannot stand on them. It has a mouth which serves for nothing else than to swallow when food is placed in it. Even its senses are, at that early season, more the inlets of pain than of pleasure, if by any chance it is long left to itself. During the continuance of this state of helplessness, however, the creature is not uncared for. Others do for it what it cannot do for itself. So long as it is an infant, kind parents watch over it, supply all its wants, and protect it from every harm.

2. But there are some creatures, besides the individuals of the human race, that are taken care of by their parents when they first enter upon the terrestrial scene. Unfledged birds are kept in the warm nest, and are fed with insects, brought to them by the parental birds, until they are able to flit through the air in pursuit of their own prey. Young lions and tigers are supplied with food, through the expeditions of the old animals, until they can hunt in the forest for themselves. All this, however, ceases among the brute creation very soon. In a few short days or weeks at most, the animal powers of the offspring are matured, and they are then beaten off from the nest or lair, and are left to seek their own fortunes, and to make their own way. Man, on the other hand, is retained in his earliest home week after week, month after month, and year after year. The parental care is given, not only to the perfecting of the body of the child, but also to the training of the mind. Man does not go through life merely by following the dictates of certain blind impulses that drive him to do particular things. He reasons before he acts. He observes, weighs, and judges, and then does what his judgment and his conscience tell him it will be well for him to do. But the mental faculties, by which man forms his judgments and determines on his actions, are of very slow growth. It takes years to educate them, and their education can only be perfected by a special training, effected through the agency of wise and experienced teachers; it can only be made complete by bringing the accumulated gains of past generations to bear on its operations.

3. Man alone is capable of being educated, in the proper sense of the term, and, indeed, alone needs to be so. The bee flies off about its business of collecting honey the moment it issues, a winged creature, from its waxen cell, and, on the instant, it performs this business as accurately and as well as the oldest sage of the bee fraternity, who has been practising the operation for months during long summer days. But man does nothing but bungle and fail in his earliest attempts at making himself useful. He tumbles down even when he first tries to walk, and in fact has to learn to do so before he can go alone. And so also in other higher operations. The slow and gradual way in which his various faculties are matured, and the necessity of his being carefully educated in order that those faculties may acquire their proper pitch of activity and perfection, evince at once that man was meant to be dependent upon his fellows to a very considerable extent; that he was designed, in fact, for social being.

4. There is one power of a very peculiar kind, which human beings possess, but which none of the lower animals have in common with them. Each individual is able to make other persons near acquainted with the feelings he is experiencing, or with the thoughts that are passing through his mind. He does this through the instrumentality of what is termed articulate speech. He produces a series of distinct sounds, by altering the shape and size of his mouth as the tones of his voice pass through it; he groups these distinct sounds together in various ways, and then enters into an understanding with his neighbours that certain of these groups of distinct and distinguishable sounds shall be taken to represent certain meanings. Thus he sends down from his brain, which is the seat of his mind, an intimation to his organs of voice and speech that he wishes them to take a certain form and do certain things; they accomplish this, and the articulate sounds "stand up," perhaps, issue through his mouth. The person at whom he is looking hears this sound, knows by previous

arrangement what it means, and directs the muscles of his trunk and limbs to give effect to the intimated wish. In all this, there is a true telegraphic mode of intercommunication put into activity. Language is, after all, but a system of telegraphic signs, determined by mutual consent, and employed in particular ways. The only essential difference between the working of the speech-telegraph and other telegraphs is, that the apparatus does not "*write signs afar*," but sounds them afar. The signs recognised as standing for certain things are audible sounds instead of being visible positions.

5. Now this faculty of communicating thoughts to one's fellows, by articulate sounds, implies several important things. It implies that the mouth shall be so framed that its shape and size can be readily altered in a variety of ways; that the mind shall be so constituted that the precise change wished for can be directed, that the exact idea desired to be expressed can be connected therewith, and that the minds of those who are around, listening to the sounds, shall be able to entertain the same ideas, and to understand the sounds as being the representatives of those ideas. The fact that man can produce the vocal sounds that stand as the signs of his meaning, and that his neighbour can hear those sounds, and understand them as expressions of his meaning when he hears them—the fact that he and his neighbour have been able to agree upon the details of a complicated, vocal, telegraphic communication, and that they have been able to put those details into practical and successful operation, proves that men were purposed to live together, and to influence each other; that, in fact, they were designed to exist in the social state.

6. But individuals not only derive strength from the relations that connect them with their fellow-creatures, they also receive from these happiness of a very intense and elevated kind. Long before I was sensible of any gain that could come to me in consequence of the act,

I clung to my nurse. I did so merely because I felt great pleasure in the clinging. After I had left my nurse's arms, I always ran to my playmates whenever I had the chance of joining them. I did this because I found myself more happy in their companionship than when I was alone. I constantly see wise old men seeking out people who are willing to listen to their conversation, and I am sure they do so because it is an enjoyment to them to communicate their reflections and their thoughts to creatures capable of entertaining like notions with themselves. The first strong impressions I experienced in life were feelings of affection and love. I can still remember kind, warm faces that used to look down upon me in my cradle, and that seemed to shed with their looks a genial sunshine that reached to the inner springs of my being. Out of the inner springs, thus genially influenced, have flown streams of delight that appear as if they could never run dry. I never now chance to see a human countenance contemplating me with gentleness and smiles, but I am stirred by some irresistible impulse acting from within to give it gentleness for gentleness and smiles for smiles. The fact is, I have been made with a great susceptibility to entertain affection for all who offer any indication that they feel the same for me, and I have also been furnished with a nature that causes me to find intense delight in loving my fellow-creatures. Hence I seek the companionship of my race that I may receive demonstrations of affection, and that I may enjoy the delight of loving. But this experience of mine is also the experience of mankind at large, and hence it may be safely inferred that men are intended to dwell in the companionship of men.

7. Yet again—people not only love all who seem to be ready to love them; they are also influenced by a very anxious and earnest desire that those they live with shall love them. They cannot really be happy, or even satisfied, without the belief that they possess their fellow-creatures' love. If a solitary man were dwelling amidst a crowd of statues that were able to render

him every possible service he could require, and did render him such service, but that were at the same time quite incapable of entertaining any sentiment of sympathy or affection for him, he would be as utterly miserable as any forlorn Robinson Crusoe, cast away upon a desolate island in the wide Pacific, although possessing every comfort and luxury of life. Nay, if he knew that the statues which served him sympathized with and loved each other, while he alone was excluded from such fellowship, he would be far more wretched than if confined in absolute solitude. Dwelling, however, as men do in the midst of fellow-creatures who are made like themselves, there is no fear that any one need ever find his demonstrations of affection slighted and without return. Each individual's ready susceptibility to love his companions insures the return of that love. All persons are alike ready to answer demonstrations of affection. And thus every one's great desire for the love of others, taken in connection with his readiness to love, proves his own fitness and predestination to the social life.

8. Love is made up of two distinct things: when I love my brother, I enjoy pleasure from seeing him, from talking to him, and from hearing him speak to me. But I also wish him a great many good things. Love consists, then, of pleasure felt in contemplating an object, conjoined to a desire for the increase of that object's happiness. Whoever really loves, feels both the pleasure and the desire, and thus love becomes an incitement to men to try to do something, besides being a state of pleasurable existence. It makes all endeavour to render those around them the better and the happier from their relations to them. This is the use of love. But whenever men do that which they believe will make their fellow-creatures better or happier, a feeling of approbation of their own conduct comes over their minds. They cannot help believing that those who are sensible of their actions will love them on account of them, or would do so if aware of them. Hence, as men desire to be loved

and are happy in being loved, they are also happy by anticipation in doing what they believe either will bring, or ought to bring, the reward that is prized. Thus, through every one's own experience of the fact that his love of his fellow-creatures makes him strive to be useful and serviceable to them, and that he is very happy whenever he believes he has done anything that will be attended with such a result, the truth is learned that, from the first, man must have been intended for society.

BE KIND TO EACH OTHER.

Be kind to each other, through weal and through wo,
For there's many a sorrow for hearts here below;
The storms of this life beat around us in vain,
If we're kind to each other in pleasure and pain.

Be kind to each other when life is all light,
When music and mirth please the ear of the night;
When pleasure spreads roses in grandeur's gay hall,
Be kind to each other and fear not at all.

Be kind to each other in sorrow and grief,
'Tis sympathy only can give thee relief;
Dividing our sorrow but lessens our pain,
Be kind to each other—affliction is vain.

Be kind to each other when sickness has come,
Let nothing but smiles ever visit your home:
Encourage and succour, and soothe the distressed,
Be kind to each other, and still thou art blessed.

Be kind to each other through life to its close,
And when thou art freed from its wishes and woes,
When freed from life's tears, from its sorrow and sighs,
Be kind to each other—and meet in the skies.

9. Division of Labour.—We have seen that men live in society because their natural disposition kept them together from the beginning, and not because, after first experiencing the inconveniences of savage life, they finally united in order to avoid them. And if we consider for a moment the manner in which the benefits

of "civilization" are occasioned, we must arrive at the same conclusion.

10. If a barbarous and a civilized community be compared with one another, it will be observed that, among the latter, each person in general cultivates exclusively some one of the many trades, professions, or occupations pursued by his fellow-countrymen, while the savage adopts, turn about, the few that are practised by his tribe, instead of devoting himself to any one in particular. But, unless a man be accustomed to his work, it cannot be well done; and this is the reason why among savages, where no one continues long at any one occupation, all are badly performed; the people in consequence are miserably poor, ill supplied alike with the various comforts and luxuries afforded by civilization. To inquire, therefore, into the means by which the material benefits derived from the social union are effected, is to inquire into the origin of the separation of employments, or, as it is more commonly called, the "division of labour."

11. What then, it may be asked, gives rise to this? Why does one man devote himself to the roundabout process of working for others, and receiving in exchange for his labour hire from which he can procure what he wants, instead of endeavouring directly to make everything for himself? It is not from the love of his species. The shipbuilder, for instance, may perhaps have the good of the human race much at heart, and rejoice at the benefits conferred by navigation and commerce; but he may, on the other hand, be of an unreflecting turn of mind, and never think of the blessings he is instrumental in promoting; or, even he may, like the misanthrope, wish ill to his brother members of society; yet whether his nature be benevolent, indifferent, or unfeeling, he pursues his art, and it is equally serviceable to mankind. He does so because he is enabled thereby to obtain, by the price of his labour, a far greater amount of whatever he desires for his support and comfort than if he applied himself to making his own furniture, building his own house, and raising his own

food, like the savage who endeavours to perform all these offices for himself, and who is, in consequence, very badly supplied with food, lodging, and everything else required to satisfy the demands of human nature. But it is neither the benefit conferred upon the community by the separation of employments, nor that resulting to each individual from its adoption, which leads to the practice. Most people rarely think of the former, or of the means by which the latter is effected. And as a general rule few people could give any better reason for that separation of employments which they are instrumental in carrying out, and to which they owe so much, than that such was the custom in the days of their forefathers, and so it has been handed down to present times. This, if we required further proof, shows us that society cannot have been the work of human design. Since when, even in our existing state of high intelligence, so few are capable of estimating how the advantages of the division of labour arise, it is evidently impossible they could ever have been foreseen, and men must, therefore, under such circumstances, have been left without any inducement to change their social condition. And if such be the case with beings of refined intellect and clear understanding, does not the argument apply with tenfold strength to ignorant savages? How could they have predicted the blessings of society, and if they could not what motives had they to take the trouble of abandoning their rude and unrestrained manner of living, and subjecting themselves to the trammels of civilization?—JAMES SEWELL WHITE.

LESSON II.

USE OF MONEY.

BY R. H. WALSH.

1. THE means by which those who are civilized provide for their subsistence differs widely from those adopted by savages. Among savages each person procures as well as he can his food, clothing, lodging, and whatever

else he stands in need of, with scarce any assistance from the rest of his tribe; and, in consequence of their not helping one another, the wants of all are very badly supplied. But where civilization prevails, the picture is reversed, each one aids the others, though often without intending it; the community, accordingly, is placed in a position of wealth and security, which to a savage would appear altogether incredible.

2. By exchanging among themselves what they produce, all this mutual assistance is afforded; and to enable them to do this with facility is the chief use of money. Were there none, much inconvenience must be experienced, as instead of merely performing the two simple operations of selling them for money, in the first instance, and then buying with the price whatever he wishes for, any one who had either his labour or goods to dispose of might be obliged to undergo the trouble of transacting a multiplicity of exchanges before turning them to a profitable account. Suppose, for instance, a shoemaker wants bread, he naturally goes to the baker to get some; but if he has nothing but shoes to offer in exchange, and the baker does not happen to want them, he cannot have what he stands in need of. The baker, however, though not requiring shoes just then, may want a coat; and the hungry shoemaker goes accordingly to the tailor to try if he will take shoes enough to pay for one. If he does, the shoemaker gets the coat, brings it to the baker, and receives bread in exchange; but if the tailor does not want shoes, the shoemaker must ascertain what he is willing to take, and then go to the person who owns such articles to try if he will sell them for shoes. This the latter may or may not agree to; and if he will not, the shoes must be carried elsewhere before the wants of their master can be satisfied, and he may thus be obliged to visit very many tradesmen indeed while seeking an opportunity of obtaining what the baker desires. All this would be very tedious; but by means of money it is avoided, as every one is willing to take it in

return for what he has to dispose of, knowing full well that when he may wish to make use of it, he can pass it on in a similar manner to the owner of what he desires, with a perfect certainty of its not being rejected. Indeed it is for this very reason that money is called the *general medium* (or instrument) *of exchange*, it affording the means of effecting all those exchanges by which the comforts and luxuries of life are distributed throughout the community.

3. It may be asked, how did people originally come to fix upon something for a general medium of exchange, and agree to give in return for the articles composing it, usually termed "coins," whatever they had to dispose of? This requires some explanation to make it quite clear; but with the aid of a little attention it cannot fail to become easily intelligible.

The natural and acquired tastes of man, his wants, fancies, and desires, are various and numerous; and many of the things which please or satisfy them are not to be had *gratuitously*, either because their production requires labour, or else from their being found at but rare intervals. In such cases, the owner will not give them for nothing (unless he wishes to make a present), as he knows that any one desiring them will be willing to give something in exchange, rather than undergo the expense, delay, and trouble of production, or wait, perhaps, for an indefinitely long period, in hopes of being favoured by chance. Now all those things which will not be parted with for nothing are said to be "valuable." But though a valuable article will not be parted with for nothing, yet it may often happen that persons, on certain occasions, will not feel disposed to give anything for it, because they may have no immediate use for it, and may not like to keep it until they require it, or find some one who is willing to buy it. Any valuable article, it is evident, exposed to such uncertainty of demand, would not answer for money; it should be something which *every* one is willing to receive, at *all* times, for what he has to dispose of; and in order to discover why certain particular valuable articles have been universally selected for money by all civilized nations, we shall examine the peculiar qualities they possess, and so be led to ascertain why they, instead of others, have been chosen for the general medium of exchange.

4. PRECIOUS METALS WHY BEST SUITED FOR MONEY. —The articles usually employed as money are metals, gold and silver especially; and if we consider why they are so, this general preference will not surprise us. Their beauty naturally attracted attention in the first instance, and caused them to be prized as ornaments; and as, unless when found accidentally, which happens but seldom, they cannot be obtained without being worked for, they are articles of value and objects of exchange.

This shows us why persons desiring gold or silver as ornaments, or to use them in any other way, will be willing to give something in return for them; yet it is not enough to account for the fact that they are always ready to take them in exchange for what they have to dispose of, even when they have no immediate use to put them to; while, on the contrary, most other articles will not in general be taken unless by some one who wants soon to employ them himself, and does not calculate on parting with them to purchase something else.

5. There are certain qualities coexisting in the precious metals which occasion this universal disposition to receive them in exchange; and though many other things share with them the possession of one or more of these attributes in a greater or lesser degree, yet it will appear on examination that they are deficient in others. Gold and silver *last* for a considerable period without suffering injury from time or exposure, and this conduces much to their employment as a general medium of exchange; persons naturally preferring for such a purpose what will not lose its useful or agreeable properties while they keep it. The stock of a fishmonger spoils in a few days, and that of a butcher is but little

more durable; and were either of these to be employed as money, the chances are they would be found worthless from decay when the owner wanted to spend them.

Again, the precious metals are very *portable*,—that is, a very small quantity of either will be worth a great deal of most things we wish to buy; and this strongly recommends them to us as money. In an age of insecurity, when all who have amassed a little property are in danger of being deprived of it, those who have any will be anxious to take the precious metals in exchange for their other goods, of a more bulky description, as in that way they can with greater facility conceal what they possess from their rapacious rulers or dishonest neighbours, or remove it when necessary to some place of security.

This quality of portability is not to be deemed useful in such an imperfect social state alone, being also eminently serviceable in the peaceful pursuits of trade and commerce. The price of a horse or cow would prove a serious load if it were to be paid in corn or cloth; but it is easy to carry about the price of several in gold or even silver money.

6. Besides the preceding recommendations, the facility with which the precious metals admit of *division* and *composition*, without any loss of quantity and at a trifling expense, renders them peculiarly adapted to supply a general medium of exchange, by removing the objections that would otherwise oppose this transition from form to form, or from size to size, according to the exigencies of trade. In an instance already given, even if the tailor wanted bread, and the baker a coat, yet no exchange could be made between them if the one did not want as much bread as would pay for a coat. But metallic money may be had of all sizes, so as to afford the means of transacting the smallest purchases, while if a coat were cut up it would be altoether destroyed. And in this point of view, metals have a great advantage over precious stones, which

as far as durability and portability are concerned, may seem equally suitable to serve as money. A diamond, once subdivided, could never be reunited so as to present its pristine beauty; and accordingly the fragments, taken altogether, do not possess their former worth. Hence diamonds, and all other things which do not admit of division and composition without loss, are very unsuited for use as a medium of exchange, since persons would be unwilling to subdivide them so as to fit them for being employed in the different small purchases which so often take place.

7. In addition to what has been already noticed, many minor advantages are possessed by the precious metals; and they have one that is very important not yet adverted to, and that is their *steadiness in value*. An article is said to remain steady in value when the quantity of goods of each kind, that may be had in exchange for it, remains the same, unless in so far as an alteration may be occasioned with respect to some, by causes rendering them in particular more abundant or scarce than usual. Hence we see why steadiness in value furnishes a strong inducement towards employing any article as the general medium of exchange; since if it changed frequently, many would be unwilling to receive it, fearing it might be worth less when they wanted to dispose of it, and others would occasionally be unwilling to part with it, thinking they might be enabled to gain more by retaining it a little longer. But, it is evident, an article which people might often be unwilling to accept in return for what they had to dispose of, or to give in exchange for what they required, must be very ill adapted to serve as money.

8. PRECIOUS METALS WHY STEADY IN VALUE.—Without entering fully into the details of this subject, it will be sufficient to point out that our existing supply of the precious metals is the accumulation of thousands of years; and it is, therefore, exceedingly unlikely that it will be rendered much more abundant or scarce than usual by changes in the amount produced during a few seasons. With most other articles, some from their

very nature are incapable of long duration, and perish rapidly in spite of any efforts to preserve them; others, like the wood and iron employed in machinery, are subjected to such violent usage that they must soon wear away notwithstanding their natural durability. There are certain things, as, for example, the different kinds of food, the destruction of which is the immediate effect of using them. And there are many others, like the generality of articles of clothing and furniture, which, when once devoted to a particular purpose, cannot well be turned to any other use; so that, should a change in custom or fashion occur, they may really be lost to the world just as much as if, in the absence of such an event, a large amount of any of them had been destroyed by some accident.

9. With all, like the preceding it is impossible the available supply in existence at any time can comprise the production of many years; and should, therefore, much more or less than usual be obtained during any one, the entire quantity may be considerably affected, and its value altered in proportion. For example, of the quantity of corn existing at any time, the greater part has been produced at the preceding harvest, and therefore both the amount and value are as variable as the seasons. But as for gold and silver, which are in their nature so very durable—not subject to be consumed with rust like other metals, or to fall rapidly into decay like the generality of animal and vegetable products—which, whether in the shape of money, ornament, or bullion, may readily be melted down without suffering diminution, and altered from one destination to another according to the requirements of the day—it is plain that our available stock of them at any time must comprise the results of the labours of ages, and any increase or diminution in the rate of production during a few of the closing years of the series will but slightly affect the entire supply. If you travel one hour on foot, and another by rail, at the end of the two you will have gone many times as far as if

you had remained walking; but, if after going nearly a twelvemonth on foot, you take a train for the last hour, very little will be gained at the end of the year by the rapidity with which you travel towards the close of it. And so, in like manner, improvement or deterioration in the production of any article will soon leave us much more or less of it than usual if the previous supply had been raised in a short time; while, had it been the result of the labours of ages, corresponding alterations, in an equally brief period, would occasion but little difference in the total quantity, and require to be in operation for a considerable time to produce such a change in value as would be rapidly effected in the other case.

10. Errors respecting Money.—It is said by some that gold and silver are not naturally better suited for money than many other articles, and that mere arbitrary fancy, not the dictates of reason, induce men to give them a preference. We have seen the error of this already, and found on examination that the general adoption of the precious metals as money was but the result of their answering best for the purpose. It is true there are a few exceptions to their employment in this capacity, but these are confined to semi-barbarous nations, and are of rare occurrence. Thus there are tribes of negroes who use as money little shells called cowries, which serve also as ornaments for their women; and in other regions, pieces of cloth answer the same purpose, and are taken in exchange for all kinds of goods, even by persons who do not intend to wear the cloth themselves, but to pay it away in return for something else. But all these descriptions of money are extremely inconvenient, and are used only by those too ignorant to perceive the superiority of the precious metals, or too poor to obtain them. The most civilized nations, indeed, do not confine themselves to gold and silver but use likewise coins of copper, or other base metal. This, however, is but to an inconsiderable extent compared with the precious metals, and solely for the purpose of transacting purchases so trifling in amount that gold

or silver coins small enough to effect them would prove most perplexingly minute.

11. Bank notes are far more convenient for making large purchases than either gold or silver, as they can be carried about with less trouble. But it is a mistake to suppose they are money. They are merely promises to pay money; and unless it is believed that these promises will be fulfilled when required, the notes must become like so much waste paper. There are persons who imagine that a coin, like a note, derives its value from the characters imprinted on it; but they should remember that the sovereign, shilling, and farthing, resembling each other pretty closely in size, are all equally impressed with the royal image; yet the first is worth twenty of the second, and nine hundred and sixty of the third. And besides, when there were no stamps, gold, silver, and copper were used as money, and at a corresponding difference in value. The use of stamping is to tell people at once what money is worth, without putting them to the trouble of weighing it, as Abraham had to do when buying from Ephron the cave of Machpelah; or of performing the still more troublesome operation of "assaying," that is of testing the purity of the metals. It may be said that a person seldom knows how much there should be in any coin, and, therefore, that the stamp gives him no useful information; he knows, however, that, whatever it contains, it is of a uniform and fixed value, and similar to that referred to in the different accounts of prices, by reference to which, he learns at what rate he should buy or sell. If a person hears that wool is selling at so much per pound, or wheat at so much the quarter, he knows at once what he ought to receive for his wool or wheat; but if there were no coined money, and gold and silver were used in buying and selling without being stamped and assayed, then although a farmer or trader might know quite well from published accounts of prices, or conversation with others, that his produce was worth so many ounces of either gold or silver, yet he would be

sorely puzzled, when disposing of his goods, to ascertain if the precious metals offered in exchange for them were really of the weight and fineness they were said to be. The weight, it is true, by a little trouble, he might discover with sufficient accuracy; but to ascertain the fineness would be beyond the ability of far the greater number of people; and hence in the absence of coined money, they would find it very hard to satisfy themselves that they really received the prices which the buyers said they gave.

12. It is not unusual to hear the love of money spoken of as avarice, which makes it be imagined that there would be no avarice were there no money. But this is incorrect. An avaricious man is one who desires to amass as much as he can of the good things of this world, wholly regardless of the wants of his neighbours. His hoards consist of money when it is to be had; but then it is merely the instrument with which he effects his selfish purpose, just as it is that by which the charitable and humane so often distribute their bounty. Were there no money the miser would not be the less a miser though his hoards consisted of other articles; and the charitable would not feel the less well disposed, though left without so convenient a means for carrying out their good intentions. In the days of the Apostles, on the occasion of a great famine, the Greek Christians contributed towards the relief of their brethren in Judea, by sending them whatever money they could spare. And just in a similar way, the contributions of almost every nation in the world were sent a few years ago to those suffering from the dreadful famine in Ireland. Without the aid of money, all the benevolent who came forward on these and similar occasions would have found it very hard to carry out their good intentions. Some of them might not have food to spare, their own country being badly supplied; or, even if they had, they might not know how to transmit it to the sufferers, at least without ruinous expense and trouble. But by keeping them provided with money, all difficulty

was got over, the corn merchants taking care that food must follow. From experience and practice, these merchants are enabled to ascertain when and where corn can be obtained in the greatest abundance, and how conveyed at the cheapest rate; and as it is by selling they make their fortunes, they are sure to bring it to every place where there are people in want of it, with money to pay for it.

LESSON III.

RICH AND POOR.

1. **When** we see some rich and comfortable, and many others poor and wretched, we are often disposed to imagine the wealth of the few to be so much taken away from the means of satisfying the wants of the many; or, in fact, that it is because some are rich, that others must be poor, there not being enough for all, and that, therefore, the proper way of correcting so great an injustice is to deprive the affluent of their superfluities and divide them among the destitute. But this is quite a mistake, as will plainly appear if we consider the manner in which wealth is accumulated and people grow rich; for we shall then find as a general rule that the fortune of any one person cannot with truth be said to have been taken away from the rest, since without his exertions, or those of the parents, friends, or relations who gave it to him, it would not be in existence at all. And it may also be shown that so far from the poor being worse off owing to the rich, they would be in an infinitely more wretched condition without them.

2. **Why some are Rich and others Poor.**—With respect to their means, the community may be divided into three classes: those who are not always able to provide themselves and their families with the necessaries of life; those who are fully able to do so much but no more; and those who can afford to indulge

in superfluities. The second class have little reason to complain of their condition, and are probably the happiest of all. Exempt from the actual privations, or fear of privation, which harass those below them, their incessant industry preserves them likewise from the bodily diseases and mental wretchedness which so often find their way to the houses of those not compelled to earn their bread with the sweat of their brow. It is true no wealthy person feels willing to quit his own class and descend to one beneath it, and, if forced to do so by some unexpected calamity, is generally less contented than before. But the reason is that he feels the loss of that affluence to which he had been accustomed, and of the consideration attached to it, which those who had been born in the lower position can never miss, because never habituated to. So it is no argument against the superior felicity of a particular class, to say that those who remove to it from another, find it unpleasant.

3. At a certain town on the side of the mountain chain of the Andes, the temperature is cool and salubrious, far more agreeable and wholesome than the rigours of the heights, or the heat of the plains and valleys; yet if an inhabitant of the latter visits this town, or its neighbourhood, he shivers at the change, just like the rich man when driven from his sheltered position by the storms of adversity. But leaving out of consideration this intermediate class of people as not presenting, when compared with the rest of the community, any extraordinary misery to be alleviated, or any superfluous wealth to be curtailed, the relative position of the rich and poor invites our attention; and the first question which naturally arises is, how does it happen that one class of persons is rich and the other poor?

4. When any one is unusually rich, the reason is that either he, or some of his ancestors, has been more industrious, provident, skilful, or intellectual than his neighbours, and so has been able to make a greater fortune in his walk of life. One, by his superior knowledge of

trade, becomes a great merchant; another attains his wealth as a manufacturer; and a third, by legal acquirements or medical skill, attains the highest eminence in his profession. The fortune thus acquired is invested in the purchase of land or other kind of property, which affords the owner an income without his being obliged to take any further trouble; this he may keep for himself as long as he lives, and leave to his children or to any one else he pleases; and then he or they are said to be possessed of riches. But who is worse off on that account? He himself has earned his wealth, or that with which he purchased it; and had he not done so, his wealth would not have been in existence, nor his neighbours one bit the richer.

5. It happens indeed occasionally that a fortune is made by plundering the property of others during foreign or civil war, overreaching them in the course of business, by unfair litigation, or other still more objectionable practices. But these occurrences are happily rare, and far the greater part of riches has been fairly and honestly acquired. With respect to landed property, however, this fact is often concealed by a foolish family pride, which induces numbers to pretend their property was made in a less commendable manner than it really was. It is thought a high distinction to be descended from the Norman chiefs who accompanied William the Conqueror, and numbers lay claim to it without cause, and represent that they derived their property from those who earned it originally by driving out the lawful owners. Many take them at their word, and then say, not unnaturally, that the right to landed property is founded on ancient robbery. But if an unreasonable pride of birth did not lead to a suppression of truth, this right could be traced to a far more creditable source, and be shown to have originated in the honest earnings of eminent merchants, traders, manufacturers, and professional men within the last few centuries.

6. As the history of riches proves that they are owing for the most part to the industry of their possessor, or

those who endowed him, instead of being so much taken away or withheld unjustly from the poor, so also if the causes of poverty be examined, an analogous lesson will be learned, and it will be found that the common reason of men being unusually poor is that either they, or those on whom they depended, have been less diligent in their occupation than their neighbours, or less prudent in general conduct, and not that others have deprived them of what they were justly entitled to. Sometimes unexpected misfortune, ill health, or other calamities, lead to extreme poverty, without any fault or folly on the part of the sufferers; but cases of this nature are exceptional, like those in which riches have been acquired by other means than industry and capability; and we may safely conclude, that as when people are rich, it is usually owing to the honest exertions of themselves or their ancestors, so also, when they are very poor, it arises from an opposite line of conduct on the part of themselves or those who brought them up.

7. CONSEQUENCE OF TAKING FROM THE RICH TO DIVIDE AMONG THE POOR.—Even although riches are fairly acquired, and poverty occasioned by the fault of those who suffer from it, might it not, it is urged, be a very good thing to put an end to all existing misery arising from privation, by taking from the Rich and dividing among the Poor? Were this done, there would soon be many poor on our hands again, as misfortune, want of industry, or bad conduct, must speedily lead several to lose or run through their shares, and so renew the numbers of the destitute. Well, then, reply those who advocate such a scheme, let a division be made over again, and poverty be corrected at the expense of wealth as often as it appears. But the difficulty is, there would soon be nothing to divide. When property has been once dealt with in this manner, it will naturally be dreaded that the operation may be repeated; and who will trouble himself to amass a greater fortune than his neighbours, if he thinks it will be taken from him for that very reason? And if any

do collect a little more than the rest, they will be sure to hide it lest they may be deprived of it, instead of using it, as at present, in giving employment. In some countries, there are tyrannical governments which incessantly oppress their subjects, and extort their property from those with whom they can discover any. And the consequence is, that nearly all are poor and wretched, as very few indeed have courage to accumulate riches which may at any time be taken away.

8. Many wealthy countries were formerly reduced to poverty in this manner, by the oppression and dishonesty of the governors sent out from the Roman Empire to rule them; and the Turkish dominions, and the northern parts of Africa tell a similar tale in modern times. They are naturally among the most fruitful regions of the earth; and once, when better governed, were thickly peopled and covered with splendid cities, the seats of flourishing commerce. But now the inhabitants are few and wretched, the cities in ruins or decay, and the commerce greatly fallen off, the industry and energy of the people being destroyed, because the motives to exert them have been removed, owing to the danger which exists of those who realize property being forthwith deprived of it by the rapacity of their rulers. And in some barbarous states, where in fact there is no government at all, matters are far worse; for even a bad government affords some slight protection to the subject; but if there is none, then any one who owns a little wealth, at once becomes an object of plunder to the rest, and is wholly without means of defence against their cupidity; and while such is the case, the motives to collect riches are altogether wanting, and every one must be sunk in the lowest depths of poverty.

9. It has now been explained that if riches be taken away from their owners, and distributed among the poor, the result will be in the end, not to leave the latter in easy circumstances, but to reduce all to poverty, since people will cease to make fortunes which may at any moment be confiscated. But why not, it may be

said, seize whatever has been gained by fraud and rapine in bygone days, and give it to the destitute? We shall not then be depriving the industrious, the energetic, and the talented of their just reward, or discouraging them from exerting their useful qualities. It is better, however, not to try this experiment, as the good to result would be doubtful, and the evil certain. And, besides, who could ever feel secure of his property if liable to be deprived of it on the grounds of its having been improperly acquired, at some period so remote that he might be altogether ignorant as to whether the accusation was true or false; and, if untrue, might yet find it impossible or extremely troublesome to collect evidence sufficient to defend his rights.

10. Beneficial effects of Wealth.—Not only the poor are not injured by the existence of the rich, and would receive no lasting benefit by the confiscation of their wealth; but, moreover, they are served by it at all times, and for want of it would suffer occasionally extraordinary privations. To say nothing of the usual effects of the fortunes of the wealthy in giving employment to the rest of the community, what would be done were all poor, when a sudden visitation tries to the utmost the resources of the people? Formerly, when there were very few rich, and nearly all indigent, if the general food-crops failed, a famine was the result; for the people, poor at all times, had nothing to draw upon to support themselves when the failure occurred, and in consequence they died in vast numbers. But now, if anything arises to leave very many in want of subsistence, the more charitably disposed among the wealthy are able to come forward to relieve the distressed; or else, through their representatives in parliament, agree to assist them, and levy taxes or raise loans for the purpose, should the poor-rates, which have likewise been devised for the aid of the destitute, prove *insufficient* under the circumstances for effecting the desired object.—R. H. Walsh.

Chemistry.

BY EDWARD FRANKLAND.

LESSON I.

WHAT IS CHEMISTRY?

In commencing the study of a new subject, every pupil wishes to know something of its nature, scope, objects, and advantages, and this is more particularly the case, when that subject is a science embracing such a wide field as the one we are now to enter upon. We shall therefore, partially at least, endeavour to gratify this curiosity, by shortly answering the question,—What is chemistry?

1. (1.) Chemistry is the study of one of the natural forces.—When we notice, even with a moderate amount of attention, the material objects which surround us, we cannot fail to perceive, that a large portion of them are constantly undergoing changes of a more or less striking character. Thus water, which we are accustomed to see in the liquid condition, becomes solid in winter, under the forms of ice and snow, and again, when exposed to sufficient heat, as when boiled in a tea-kettle, it is entirely converted into a colourless vapour, which mixes with the atmosphere and becomes invisible. In summer the clear sky sometimes becomes suddenly darkened by dense black clouds, from which bright flashes of lightning issue, attended by loud peals of thunder. In spring we see the small seeds, deposited in the earth by the gardener and the farmer, grow up and expand into the stems, branches, and leaves of plants. In the autumn, these leaves, becoming detached from their supports, fall to the earth, where they soon begin to decay, and rapidly disappear altogether; whilst the new iron nails, with which some of the plants had in spring been trained upon the wall, have become covered with a brown substance which we call rust.

2. Now all these changes are produced upon matter

by the operation of certain agencies, which philosophers have agreed to term *forces*. Thus the transformations of water into ice and steam are due to the operation of two forces, which act antagonistically to each other, and which are termed *heat* and *cohesion*. The phenomena of the thunder-cloud are produced by another force, which we term *electricity*. The seed is developed into the plant by the agency of the *vital force*. The leaves fall to the earth by the *force of gravity;* their decay and disappearance, and the rusting of the iron, are results of the action of the *chemical force*.

3. The force to which all the phenomena of chemistry are due, is therefore closely associated with the other great forces of nature; but it is distinguished from them by this remarkable circumstance, that whenever matter is subjected to its action, such a complete alteration in the qualities and properties of that matter takes place, as entirely to prevent our senses recognising in the product the original materials from which it was derived. Thus the principal products of the decay of leaves are gases, which do not bear the most remote resemblance to the substance from which they are derived; and no one could even suspect the presence of the bright, hard, and heavy metal iron, in the dull, soft, brown, and comparatively light rust, into which it is converted by exposure to the air. The other physical forces never produce this entire change of character; water for instance, is not essentially altered by the action of either cohesion or heat, for ice when melted, gives water with all its original properties, and the dew, which condenses upon a cold plate held in the steam, issuing from the spout of a tea-kettle, is also pure water with all its properties unimpaired. Again the fragments of stone split off from a church tower by a stroke of lightning, have all the properties and qualities of the mass from which they were derived; and the leaves of a plant just fallen to the earth, have undergone no alteration during their fall. Whilst chemistry, therefore, forms a part of physics or natural philosophy, which is

the science of the natural forces, it is distinguished by being the study of that particular force, which completely changes the character, and qualities of the materials upon which it acts.

4. (2.) CHEMISTRY EXHIBITS TO US REMARKABLE TRANSFORMATIONS.—The chemical force is essentially a transforming force: wherever it is exerted, a change of a more or less striking nature occurs in the appearance and qualities of the bodies submitted to its action. A change in the state of aggregation or physical condition of matter sometimes takes place, liquids being converted into solids, as when concentrated sulphuric acid is added to a strong solution of chloride of calcium, or liquids and solids into gases, as when acetic acid is poured upon chalk or marble; at other times it is attended by a striking change of colour, as when a colourless solution of iodide of potassium is added to a colourless solution of acetate of lead, and an intensely yellow coloured body is the result; or a dilute solution of yellow prussiate of potash (nearly colourless), to a weak solution of perchloride of iron (nearly colourless), when a splendid blue compound is formed.

5. Chemical action is frequently accompanied by a change of temperature: thus great heat is evolved, when quicklime combines chemically with water, in the process commonly called slaking of lime; and a considerable degree of cold is produced when powdered sulphate of soda is mixed with muriatic acid: if about two ounces of each of these ingredients be mixed in a thin tumbler, placed in a warm room, the exterior surface of the tumbler will soon become coated with hoar frost. Sometimes the elevation of temperature is so great as to produce ignition: thus when a small piece of phosphorus is brought into contact with a few grains of iodine, it bursts into flame, and continues to burn until both materials are dissipated in a mixture of white and violet fumes. The sudden evolution of gaseous matter during chemical action causes explosion, as when gunpowder is ignited. A less rapid disengagement of gas produces

effervescence, such as is seen when a mixture of carbonate of soda and tartaric acid is thrown into water.

6. A remarkable change in the taste of bodies frequently attends chemical action: thus if chloride of silver be dissolved in solution of hyposulphite of soda (a very nauseous liquid), the most intensely sweet compound known is produced. Corresponding transformations not unfrequently take place in the odour of bodies, thus chloride of ammonium and slaked lime are both inodorous, but when mixed together in the state of powder, they produce one of the most pungent bodies known,—ammonia; and on the other hand ammonia and sulphurous acid, both very pungent, when mixed together in certain proportions, produce a perfectly inodorous compound.

7. A change in the medicinal properties of bodies almost invariably follows chemical action; thus chlorine, a very suffocating and poisonous gas, and sodium, a bright metal which ignites when moistened with water, and which would therefore be fatal to animal life if taken internally, unite chemically to form common salt (chloride of sodium). Arsenious acid, one of the most poisonous substance known, combines with peroxide of iron to form a perfectly harmless compound. The elements composing the atmosphere produce, when chemically united, the highly poisonous nitric acid, and the constituents of our daily food can be transformed by the action of the chemical force into the most deadly poisons.

8. Many processes in the chemical arts strikingly exemplify the remarkable transformations effected by chemical affinity: old woollen rags, the refuse of tanyards, and rusty scraps of old iron, are made to yield dyes of the richest hue; and that nauseous black material, coal tar, so repugnant to every one, becomes transformed by the same magical influence, into the most delicious perfumes, rivalling in fragrance and delicacy the exhalations of the sweetest flowers and fruits. In like manner, rags and sawdust are transformed at will into

starch, or grape sugar, whilst the produce of our coal mines is not only converted into a colourless and invisible gas, affording us brilliant light, but can be also made to yield beautiful white candles, which almost surpass wax and spermaceti in purity of flame and illuminating power.

9. (3.) CHEMISTRY TEACHES US THE COMPOSITION, ANALYSIS, AND SYNTHESIS OF BODIES.—If we examine the materials composing the globe we inhabit, it will be at once perceived, that they are made up of different kinds of matter; in fact, if our examination be somewhat extensive, we shall very probably form the opinion that such an immense variety of matter as we meet with in the animal, vegetable, and mineral kingdoms, must be composed of an almost unlimited number of substances; yet a more accurate inspection proves to us, that this infinite variety of form and appearance is produced by the combination of a comparatively small number of first principles or elements. Although every variety of matter hitherto noticed has been submitted to chemical investigation, chemists have only detected sixty-two of these elementary principles, and, therefore, every kind of matter with which we are acquainted, consists either of one of these elements or of a combination of two or more of them. By the aid of chemical processes all matter can be resolved into its elements: thus chloride of sodium (common salt) can, by certain chemical processes, be decomposed into chlorine and sodium; and, in like manner, water can be broken up into two gases, oxygen and hydrogen; but by no means at present known can we extract anything from chlorine, sodium, oxygen, or hydrogen; by no treatment can these bodies be decomposed into two or more parts or constituents, and we therefore term them *elements*, or forms of matter which cannot be decomposed. It is however quite possible, that the further progress of science will enable us to decompose many of the substances which we are at present compelled to consider as elements.

10. The processes just alluded to, by which all matter is resolved into its elements, are *analytical* processes, and this branch of chemistry is termed *chemical analysis*. Chemical analysis thus teaches us the composition of matter, and enables us to ascertain the possibility of extracting any required substance from a given material. It was their very imperfect acquaintance with this branch of the science that led the ancient alchemists to entertain such sanguine hopes of being able to succeed in extracting gold and silver from the baser metallic elements, such as lead and copper. Chemical analysis enables us also to detect the presence of poisonous substances, and thus frequently leads to the preservation of health, or to the demonstration of the cause of death.

11. When, by the aid of chemical analysis, we have ascertained the composition of any substance, we can then proceed to attempt its artificial formation, by bringing together its elements and causing them to combine chemically; thus the analysis of common salt proves that it is composed of chlorine and sodium, and by bringing together these elements, they immediately unite and reproduce common salt. Operations of this latter description are termed *synthetical* processes, and this branch of chemistry is designated *chemical synthesis*. It is evidently possible, by synthetical processes, to bring together such elements as are not found united in nature, and thus to produce new compounds; and in fact large numbers of entirely new substances have in this way been formed, many of them possessed of very valuable and extraordinary properties. But synthetical processes are by no means uniformly successful; since there are many natural compounds, especially in the animal and vegetable kingdoms, which we have not yet succeeded in reproducing from their elements; for we not only cannot produce artificially a piece of cane, or a fragment of blubber, but we cannot even form from their elements, the sugar of the one, or the oil of the other.

12. (4.) CHEMISTRY ENABLES US TO INVENT AND

PERFECT MANUFACTURES, AND TO IMPROVE MEDICINE AND AGRICULTURE.—Whilst chemistry is in itself one of the most pleasing and inviting studies, no science has attained a higher reputation for utility, or has done more towards increasing the happiness, comfort, and resources of mankind. The almost inexhaustible variety of chemical combinations, and the intimate connection of chemical phenomena, not only with the arts and manufactures, but even with most of the common operations of daily life, render it a subject of interest to every one, and an indispensable element in a good education.

13. If society express a new want, chemistry immediately calls into existence a new branch of manufacture to meet that want; few branches of industry pass through a year of their existence without experiencing some improvement from the resources of this science; whilst the very groundwork of medicine and agriculture rests upon the manifestations of the chemical force.

14. To illustrate fully the utility of chemistry would require much more space than the limits of this section will allow, and a few prominent instances only can therefore be here mentioned. Few modern inventions have done more to increase our national manufactures, and to cheapen important articles of consumption, than the chemical invention of bleaching by means of chlorine and chloride of lime. Thirty years ago extensive tracts of meadow-land in Lancashire and other parts of this kingdom, were covered, as with a carpet, by thousands of yards of calico. These were the so-called *bleaching grounds*, in which cotton cloth,—grey and dirty looking as it came from the loom—was spread out to the sunlight, and carefully watered for weeks or even months, before it became sufficiently whitened or bleached to fit it for domestic use, or for the further operations of the calico printer. Good meadow-land only was suited to this operation, and thus thousands of acres of the richest pasturage were rendered useless for the purposes of agriculture. This waste of fertile land,

and laborious spreading out and watering of calicoes, have been entirely superseded by the simple and cheap application of chlorine and chloride of lime, by which the whole operation can be completed in a small building in forty-eight hours. The same invention also enables us to convert the most dirty rags into beautiful white paper, and by another very recent application of it, we have even succeeded in bleaching sawdust, and transforming it into the same useful material.

15. Another chemical invention, which has proved of incalculable value, is the manufacture of coal gas, by which our streets and houses are now so brilliantly lighted: a century ago this useful and elegant illuminating agent was quite unknown, and the streets even of our metropolis were so feebly lighted, that to walk in them after nightfall was attended with considerable danger. Although coal gas might have been invented without much knowledge of chemistry, yet it could never have been made extensively useful without the appliances of this science for its purification from noxious ingredients, and for the means of burning it without inconvenience, and the risk of dangerous explosions.

16. Medicine is indebted to chemistry for a large number of curative materials, and for that most remarkable liquid, chloroform, by which the infliction of pain, during surgical operations, is avoided. It is by the aid of chemistry that some of the most interesting investigations, connected with the functions of the human body, are now being conducted, and which will enable us to preserve health, cure diseases more effectually, and thus greatly benefit mankind at large.

17. The success of the farmer, whose office it is to provide food for us, is also intimately connected with the chemical conditions necessary for the growth of nutritive crops, and for the feeding and fattening of cattle. By its aid he can render barren fields fertile, and increase the quantity of food procurable from a given area of land. It was chemistry which first pointed out the valuable deposits of guano in the western hemisphere,

and the extensive stores of fossil manure in our own country.

Thus chemistry is not only a highly interesting, but also an eminently useful branch of natural science, and one which will not fail amply to reward the diligent pupil who, by its study, becomes possessed of the key to some of the most valuable secrets of nature's treasury.

LESSON II.

CHEMICAL AFFINITY.

1. **Principal features and characteristics of the chemical force.**—The peculiar phenomena which are observed when certain dissimilar substances are brought into contact with each other, and which we term chemical phenomena, are supposed to be produced by a peculiar force or power, existing in matter, which we call the *chemical force*, or more commonly *chemical affinity*. The selection of this latter term is somewhat unfortunate, as it is very liable to lead the young student into error. In common language the term affinity signifies relationship, conformity, and resemblance between two persons or things; but so far from having the same signification in chemistry, it has rather the contrary one; for in all cases where chemical affinity is observed to exist between two substances, those substances are almost invariably of widely different character and properties, and the more prominent this difference of character, the more powerful is the chemical affinity observed to be: thus a very strong affinity exists between chlorine and iron, chlorine being a yellow transparent gas, having not the most remote resemblance to the bright, heavy, solid metal, iron. Again, between phosphorus, a solid wax-like body, and oxygen, a colourless and transparent gas, being one of the constituents of the air we breathe, there also exists a very marked affinity. The term therefore in chemistry never means resemblance, but signifies an attraction, a disposition to unite,

or the presence of that power which retains substances in chemical combination.

2. Several of the most important characteristics, by which the chemical force or chemical affinity is recognized, and distinguished from the other natural forces, have already been noticed; but there is another feature attending its operations, which serves to distinguish chemical affinity in a still more remarkable manner, and this is its *elective* character. Chemical affinity is *elective;* it selects, from amongst a number of substances, those between which it chooses to exert its power. This extraordinary attribute of the chemical force is constantly noticed in chemical reactions. Thus if we place a piece of silver and a piece of iron in a tumbler of water, we notice after the lapse of a few days, that the iron has lost its lustre, and become covered with rust, whilst the brilliant surface of the silver remains unchanged. Here one of the constituents of the atmosphere, oxygen, which was dissolved in the water, finding itself in the presence of silver and of iron, made a selection between these two metals, and preferring the iron, united exclusively with that metal. Again, if dilute sulphuric acid be poured into a clear and transparent solution of nitrate of baryta, the mixture immediately becomes milk-white and turbid, from the separation of solid sulphate of baryta, in the form of a white powder. The nitrate of baryta consists of nitric acid and baryta, and the latter, after the addition of the sulphuric acid, makes a selection between the two acids, combining with the sulphuric acid, and rejecting the nitric acid with which it was in the first instance united. Thus in addition to the peculiarities previously mentioned, by which the operations of the chemical force may be distinguished from those of other natural forces, we have this remarkable characteristic—its elective character.

3. Chemical affinity, unlike gravity, electricity, and several of the other natural forces, cannot act, unless the particles of the bodies, capable of developing it, are in

actual contact. The smallest measurable space between two bodies will effectually prevent all chemical action, no matter how intense the affinity may be; consequently, everything which tends to blend together and intimately mix the particles of matter, is favourable to the exertion of chemical affinity; whilst every circumstance which prevents the intimate contact of bodies opposes chemical action. In solids, the force of cohesion binds together the particles of each separate body, and thus prevents an intimate mixture, as well as a free mobility of particles, which is necessary to their new arrangement in a chemical compound. Wherever therefore cohesion pre-exists, it retards, or altogether prevents chemical action; although the same force, when it comes into play during chemical action, greatly promotes affinity in a manner to be subsequently described. The exertion of the chemical force is therefore promoted, by whatever tends to disintegrate and separate the particles of matter. Thus, pulverization frequently much facilitates chemical action: if we throw a lump of limestone into dilute hydrochloric acid, we find that its solution is effected very slowly; but if we first reduce the limestone to fine powder, it combines with and dissolves in the acid almost instantaneously. The same effect is exemplified in the case of carbon, as existing in tinder and in coke; the porous friable tinder, by contact with the smallest spark, easily ignites, that is, combines chemically with the oxygen of the atmosphere; whilst the hard and compact coke requires the prolonged application of a high heat, to make it enter into combustion.

4. Just as cohesion retards chemical affinity, by preventing the intimate contact of the particles of different bodies, owing to its retaining them in a more or less hard and compact state, so heat frequently produces the same effect by its repulsive action. One of the most characteristic effects of heat is expansion; an iron ball which will just pass through a circular opening when cold cannot be made to enter it, when the ball is heated to redness. By the application of a sufficient degree of

heat, the particles of all descriptions of matter can be repelled to such a distance from each other as to place them beyond the reach of the counterbalancing force of cohesion, under which circumstances they assume the gaseous form. Now the gaseous condition is unfavourable to that intimate contact, which is essential to the exertion of chemical affinity, because the particles of bodies in this condition, are mutually repelled, and entirely separated from each other; it therefore frequently happens, that two bodies, which possess the most intense affinity for each other, are yet unable to unite, owing to their being in the gaseous condition; thus the two gases oxygen and hydrogen, may remain mixed together for centuries without any combination taking place, although these gases have a very powerful affinity for each other. Again, many compounds, whose constituents are united by very intense affinities, may be completely decomposed by the repulsive action of heat, which separates their particles beyond the sphere of chemical attraction. This is the case with oxide of mercury for instance, which by the application of a red-heat is resolved into its elements—metallic mercury and oxygen gas. This reaction may be readily seen,

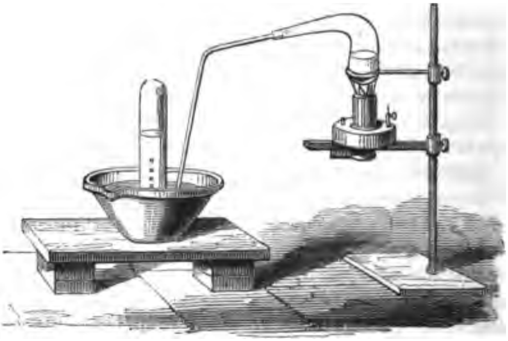


Fig. 1.

by placing half an ounce of peroxide of mercury in a small glass retort, (see fig. 1,) from which a glass tube passes to the pneumatic trough; on applying the heat of a spirit lamp beneath the retort, oxygen gas will be freely evolved, and may be collected at the pneumatic trough as shown in the figure; metallic mercury condenses in the neck of the retort. The application of a lower degree of heat, however, than that requisite for gasification, generally promotes chemical union: thus carbon and oxygen unite only at a red-heat, and most of the metals can be made to combine with oxygen readily at high temperatures only. It is probable that in these latter cases the heat acts by overcoming or neutralizing the force of cohesion, and thus permitting a free motion of the particles of bodies, which is essential to chemical action.

5. Of the three conditions of matter, viz., the solid, the liquid, and the gaseous, the liquid is by far the most favourable for the exertion of chemical affinity, because in liquids we have the two conditions—intimate contact, and free motion of particles; hence, when a chemical change is to be effected in solid bodies, we usually bring them into the liquid condition, either by solution in some appropriate solvent, or by igneous fusion; the first mode of operation is termed the *humid* or *wet way*, from water being the solvent most usually employed, and the second is designated the *dry way*.

6. The common effervescing powder forms a good illustration of the effect of liquefaction by the humid way; this powder consists of a mixture of dry carbonate of soda and tartaric acid: in the solid condition these materials do not act upon each other, but on projecting a teaspoonful of the powder into a tumbler of water, a violent chemical action is produced, attended by effervescence due to the escape of carbonic acid gas. The constituents of the powder dissolve in the water, and the requisite intimate contact and mobility of particles being thus given, every facility is afforded for the exertion of the affinity existing between the constituents

of the powder. The effect of liquefaction in the dry way is seen by fusing in a small crucible over a spirit lamp a mixture of carbonate of soda and boracic acid, two materials which exhibit no tendency to unite in the solid condition, but which exhibit a powerful chemical action, accompanied by effervescence, as soon as they become liquid. In many cases it is sufficient that one of the materials be in the liquid condition.

These facts demonstrate that the liquid state of matter is most favourable to the manifestation of chemical affinity, and that all those agencies which produce liquefaction, promote chemical action, whilst those influences which prevent liquefaction, retard it.

7. SINGLE ELECTIVE AFFINITY.—When one substance, in the presence of two others, unites exclusively with one of them, as in the case of silver and iron placed in water above-mentioned; or, when one of the constituents of a compound is expelled by the addition of another body, as when nitric acid is expelled from nitrate of baryta, by the addition of sulphuric acid, we have an example of what is termed *single elective affinity.* By observing such manifestations of chemical action, it is easy to ascertain the relative degrees of affinity existing between different bodies, and to express them in tables. Thus the affinity of sulphuric acid for several substances may be represented in this way—

8. SULPHURIC ACID:—Baryta, Strontia, Potash, Soda, Lime, Magnesia, Ammonia, and Oxide of Silver.

This table signifies that baryta can expel, from their combinations with sulphuric acid, all the substances placed below it in the list; and generally any substance in the list can be expelled from its combinations with sulphuric acid, by any other substance placed above it, and can similarly expel from their combinations the substances placed below it. But such tables, although of use in thus showing the relative chemical attraction of one substance for a number of others, are yet only of a very limited value, owing to the interference of external causes with the phenomena of chemical attraction. This circumstance causes a want of harmony between similar tables constructed for bodies which otherwise possess a close chemical analogy. Thus on ascertaining the degree of affinity of the above substances for another acid, viz., hydrochloric acid, we obtain the following results:—

9. HYDROCHLORIC ACID:—Oxide of Silver, Potash, Soda, Baryta, Strontia, Lime, Magnesia, and Ammonia.

Here we find that oxide of silver, which took the lowest place in the sulphuric-acid list, exhibits the strongest affinity for hydrochloric acid, whilst baryta and strontia, which stood at the head of the sulphuric-acid table, occupy here only an intermediate position. A further consideration of the action of chemical affinity will show that such tables do not represent merely the relative degrees of affinity, but they exhibit the results of the mutual action of this force and other external forces, which latter modify and control chemical affinity.

10. DOUBLE ELECTIVE AFFINITY.—In the instances of single elective affinity above given, one substance, in the presence of two others, selected and combined with one of the latter; but the action of chemical affinity is frequently less simple, as when two compounds, each consisting of two constituents, are made to act chemically upon each other; in such a case we have what is termed *double elective affinity*. Whilst in single elective affinity there are only three substances present, and two affinities in operation, in double elective affinity we have four substances and four affinities, brought into play. Thus if we mix together solutions of carbonate of ammonia and nitrate of baryta, we have then in the presence of each other, four substances, viz., carbonic acid and ammonia in the carbonate of ammonia, and nitric acid and baryta in the nitrate of baryta; we have also four affinities called into play, the affinity of carbonic acid for ammonia, that of the same acid for baryta, the affinity of nitric acid for ammonia, and that of the same acid for baryta. Now the

result of such a mixture will depend, to some extent at least, upon the relative energies of the different affinities called into play; if the affinity of the carbonic acid for ammonia, plus that of the nitric acid for baryta, be greater than the sum of the affinities of carbonic acid for baryta, and nitric acid for ammonia, then no change will take place; but if, on the other hand, the affinity of carbonic acid for baryta, added to that of nitric acid for ammonia, exceeds the sum of the affinities of carbonic acid for ammonia, and nitric acid for baryta, then mutual decomposition must ensue. This is what actually takes place, for on mixing the two solutions, which were previously clear and transparent, the liquid becomes milky, and a white powder, consisting of carbonate of baryta, gradually subsides, leaving nitrate of ammonia in the clear solution floating above it. By such double elective affinity decompositions are frequently effected, which are quite impracticable by mere single affinity: thus, in the instance just given, carbonic acid alone is totally incapable of abstracting baryta from nitrate of baryta, and ammonia is also equally unable to separate nitric acid from baryta; but the combined affinities of the carbonic acid for baryta, and the ammonia for nitric acid, acting simultaneously, are sufficiently powerful to produce a decomposition, which neither of the two affinities acting alone could effect.

11. To represent this play of affinities more clearly to the mind, and in a more material form, we may express the relative degrees of affinity by arbitrary numbers, and thus obtain numerical expressions for the decompositions. If we represent the affinity of carbonic acid for ammonia by the number 30, that of carbonic acid for baryta by 50, the attraction of nitric acid for ammonia by 70, and that of the same acid for baryta by 80; we then find that the forces, the *quiescent* affinities as they are sometimes termed, tending to retain the substances in their original state of combination, are as follow:—

Affinity of baryta for nitric acid	=	80
Affinity of ammonia for carbonic acid	=	30
		110

The total force retaining the constituents of the original substances in combination is therefore 110, but the forces, or *divellent* affinities, tending to produce decomposition, are the following:—

Affinity of baryta for carbonic acid	=	50
Affinity of ammonia for nitric acid	=	70
		120

which being superior to the sum of the former forces, decomposition must take place. By the assumption of these arbitrary numbers we can also obtain some notion of the reason why the single affinities acting alone could not produce decomposition, for the force retaining the baryta and nitric acid in combination is equal to 80, whilst the attraction of carbonic acid for baryta is only 50; further the affinity of nitric acid for ammonia is only 70, and therefore less than that of the same acid for baryta, consequently neither ammonia nor carbonic acid, acting singly, can decompose nitrate of baryta.

Like the decompositions produced by single elective affinity, those effected by double decomposition are almost constantly controlled and modified by the simultaneous action of external forces; and in order fully to understand the phenomena attending the exhibition of these affinities, it is therefore now necessary that we should examine somewhat into the influence of the other physical forces in modifying and controlling chemical affinity.

LESSON III.

MODIFICATION OF CHEMICAL AFFINITY BY OTHER PHYSICAL FORCES.

1. (1.) By cohesion and heat.—These antagonistic forces are amongst the most active in modifying and controlling chemical affinity. It is by their mutual

action that the state of aggregation of matter is determined. Cohesion binds together the particles of matter, and where it acts uncontrolled, or with sufficient force, it produces the solid condition. Heat, on the contrary, tends to expand matter, and thus separate its particles further asunder; it is the principle of elasticity, and, when uncontrolled by cohesion, it produces the gaseous condition of matter. Where the two forces are almost equally balanced, the liquid condition is determined.

2. From what has been already said respecting the conditions most favourable for the exertion of chemical affinity, viz., mobility and intimate contact of particles, it will be readily understood that the reciprocal action of cohesion and heat in determining the physical condition of bodies, must of necessity exercise great control over the formation and decomposition of chemical compounds. The conversion of a solid into a liquid, by the diminution of cohesive force, frequently determines the combination of that solid with a second body, upon which, previous to its liquefaction, it had no action, whilst by the further diminution of cohesive power, by the application of heat to the compound thus formed, the repulsive force may become so powerful as to supersede the chemical attraction, by which the constituents of the compound are held together; in which case decomposition occurs, and the compound is resolved into its elements. Thus, if a few pieces of quicklime and ice be placed in contact, no action takes place so long as the ice retains its solid condition; but, on the application of a sufficient temperature to liquefy the ice, the quicklime absorbs the liquid water with such intense affinity, as to occasion the evolution of considerable heat; if, however, this compound be now heated to redness, it is again resolved into its constituents—quicklime and water.

3. But cohesion can also assist chemical affinity in a very remarkable manner, when the former is brought into play between substances in solution. This effect has already been alluded to in describing the anomalies

which present themselves when we attempt to construct tables of affinity: thus, in one of these tables, representing the affinity of hydrochloric acid for various substances, it was seen that this acid possessed the strongest attraction for oxide of silver; whilst in a similar table, constructed for sulphuric acid, baryta was attracted by the strongest force, and oxide of silver by the weakest. Such anomalous results as these are due to the influence of cohesion; and under all circumstances, when bodies in solution act upon each other, the result is the formation of such compounds as are least soluble. If we dissolve a mixture of sulphate of soda and nitrate of potash in water, there occurs immediately a distribution of the two acids, sulphuric and nitric, and the two bases, soda and potash; we have thus produced sulphate of soda and nitrate of soda, sulphate of potash and nitrate of potash. All these salts remain in solution, if a sufficient amount of water be present; but they differ greatly in their solubility, and if we concentrate the solution by evaporation, we shall find that crystals of sulphate of potash are first deposited.

4. Now, if we suppose that in this way the whole of the sulphate of potash has been removed from the solution, there still then remain dissolved sulphate of soda, nitrate of soda, and nitrate of potash; but a new distribution of acids and bases again takes place, with the formation of a further quantity of sulphate of potash, which also crystallizes out on further evaporation; and this operation can thus be continued, until all sulphuric acid and potash have been removed from the solution, and nitrate of soda only remains dissolved. Keeping this reaction in view, it will be evident, that if by this distribution of acids and bases, on the mixture of two such salts, a compound be formed which is perfectly insoluble; then the ultimate effect, which was gradually produced in the case of nitrate of potash and sulphate of soda, will take place in so short a time as to appear instantaneous: thus when solutions of nitrate of baryta and sulphate of soda are mixed together, a white powder, consisting of

sulphate of baryta, is immediately thrown down, owing to its perfect insolubility in the liquid.

5. The results of double decomposition are thus almost entirely determined by the degree of solubility of the new compounds formed, and generally the decomposition occurs in that mode, by which the most insoluble compounds are generated. In the case of the decomposition of solution of nitrate of baryta by carbonate of ammonia, mentioned above, the formation of carbonate of baryta is determined, rather by this action of cohesion, than by the superiority of the divellent over the quiescent affinities.

6. Just as cohesion modifies chemical affinity, and determines the mode of decomposition, by the formation of insoluble compounds, so heat or elasticity produces analogous results by the formation of volatile compounds and their expulsion in the gaseous form. In this way the decompositions which take place under the influence of cohesion, are sometimes completely inverted, when the same materials act upon each other under the influence of heat or elasticity. Thus we have already seen that, when carbonate of ammonia and nitrate of baryta are brought together in solution, the reaction is such that nitrate of ammonia and insoluble carbonate of baryta are produced. Here the mode of decomposition is determined by the insolubility of the carbonate of baryta, but if we now mix together carbonate of baryta and nitrate of ammonia in the solid state, and apply heat to the mixture, a complete inversion of the previous decomposition takes place, and the original nitrate of baryta and carbonate of ammonia are produced; the mode of decomposition being here determined by the elasticity of the carbonate of ammonia, which is expelled from the mixture in the form of white vapours.

7. Under the influence of elasticity, affinities which in other circumstances are very feeble may be so exalted as to overcome those of the most powerful description. Thus at ordinary temperatures sulphuric acid is the strongest acid known, whilst boracic acid is one of the

weakest, and the former acid can instantly deprive the latter of any base with which it may be united; but if a mixture of sulphate of soda and boracic acid be heated to redness, the whole of the sulphuric acid will be expelled in the form of vapour, and borate of soda will remain; this result being determined by the superior volatility of the sulphuric acid, which vaporises at a temperature below redness, whilst boracic acid can withstand an intense white heat without volatilisation.

These modifying effects of cohesion and heat are of the most extensive application for the production of chemical changes; indeed, without such modifying influences, it would be impossible for us to break up those chemical compounds which exist in nature, and thus chemistry, and the arts which depend upon it, could never have been called into existence.

8. (2.) BY LIGHT.—Although the influence of light upon chemical affinity is in many cases very striking, and has been the subject of numerous investigations, yet the attempts to elucidate any general principles, by which this influence is governed, have not hitherto been successful; we shall not therefore do more here than illustrate the modifying effects of this force by a few examples of its mode of action.

The influence of light upon chemical affinity may be described as of a twofold and opposite character, for it sometimes greatly promotes chemical union, whilst at other times it exerts a powerful decomposing effect. There are four elements, upon the chemical reactions of which, light appears especially to exercise great influence; these are chlorine, bromine, iodine, and silver: all the important chemical effects of light are confined to these elements and their compounds. In connection with these bodies, it has been observed, that the combining power of chlorine is generally exalted, and that of bromine little affected, whilst the affinities of iodine and silver are considerably depressed, under the influence of light. On the other hand the decomposing effect of light is greatest on the compounds of iodine, and of silver, and least upon those of chlorine and bromine.

9. The influence of light in promoting chemical affinity is very strikingly seen in the case of chlorine and hydrogen: if we mix together equal measures of these gases and preserve the mixture in the dark, no combination will take place, even if years be suffered to elapse; but if the mixture be placed in diffused daylight, combination immediately commences, and in the course of a few hours the gases have completely united and formed hydrochloric acid, which will be rendered evident on opening the vessel containing the mixture under water; the hydrochloric acid being soluble will be rapidly absorbed, whilst the water will rush violently into the vessel and occupy the place of the absorbed gas. If, instead of exposing the glass vessel containing the mixture to diffused daylight, it be suddenly placed in bright sunlight, the gases unite instantaneously with a loud explosion and bright flash of light.* The action of chlorine in bleaching, and in the disinfection of putrescent matters, is also greatly facilitated by the presence of light.

10. The decomposing effects of light are best seen by exposing iodide of ethyl to its influence; for this purpose about two drachms of the iodide may be placed in a small flask with half an ounce of mercury; the flask being then closed by a cork and bent tube, and placed in sunlight or even diffused daylight, decomposition of the iodide immediately commences; the iodine unites with the mercury, and its other constituent, ethyl, is evolved in the gaseous condition, and may be collected in the pneumatic trough, as shown in fig. 2.

In addition to these reactions produced by the influence of light, a large number of the beautiful processes of photography depend upon the same cause; but although these processes are in themselves highly interesting, yet being founded upon a number of isolated facts rather than upon general principles, their more minute description would scarcely serve further to elucidate the modifying effects of light upon chemical affinity, and it need here only be further remarked that these effects appear to be produced by one of the constituents only of compound white light; from which circumstance this constituent has received the name of the *chemical ray*.

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* As the vessel containing the gases is shattered by the violence of the explosion, this experiment ought to be made with caution. It is best performed as follows: the mixture of the gases is made in a somewhat darkened room, and the vessel, which may be a white glass-bottle, fitted with a good cork, being enveloped in a thick cloth and taken into the open air, the bottle must be suddenly withdrawn from the cloth and projected upwards.

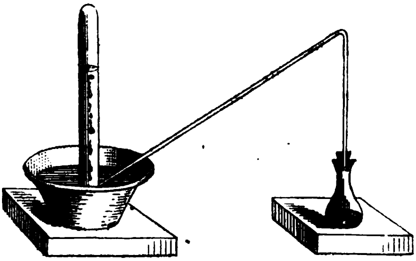


Fig. 2.

11. (3.) BY ELECTRICITY.—There is no physical force which stands in such close relation to chemical affinity as electricity; indeed, so intimately are these two forces connected, that many profound philosophers have not hesitated to regard them as having a common origin, if not as being actually identical. It would, however, be out of place here to enter into the discussions to which these views have given rise, as they involve some of the most abstruse theoretical considerations of electro-chemical science. Leaving therefore all theoretical views of the electrical condition of ultimate atoms, and the influence of this condition upon their combining powers, out of consideration, we will now only glance at the influence of electricity in producing decomposition; for it is in the decomposition of compound substances that the controlling effect of electricity upon chemical affinity is most strikingly seen.

12. In order to bring the electric force effectually to bear upon chemical compounds two conditions are necessary, viz., mobility of particles (which is attained in the

liquid condition) and power of conducting the electric current. Where these two conditions are present, electricity appears to be capable of breaking up, and decomposing the strongest chemical combinations. Voltaic electricity is best adapted for exhibiting these reactions, and its effect is seen very strikingly in the decomposition of water into its elements, oxygen and hydrogen gases. For this purpose the apparatus fig. 3 is employed; it consists of a glass vessel containing two platinum plates, fixed upon two wires of the same metal passing through the bottom of the vessel, so as to be connected with the two poles of a voltaic battery, of three or more elements. The vessel is filled with water, to which about $\frac{1}{16}$ part of sulphuric acid is added to increase its conducting power: fixed in an inverted position over the platinum plates, and filled with the same acidulated water, are two glass tubes for collecting the gases evolved. On making the connection with the battery, bubbles of gas will be observed to rise from the platinum plates, and collect in the tubes; but it will be remarked, that the gas collected in one of the tubes has twice the volume of that received in the other, and on examination it will be found that the larger volume is pure hydrogen and the smaller one oxygen gas; and further that the platinum plate from which the hydrogen was evolved is connected with the *negative* pole of the battery, and consequently that from which the oxygen was derived, with the *positive* pole.

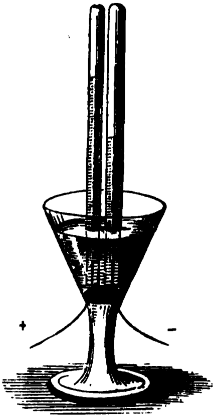


Fig. 3.

13. This latter phenomenon is always observed in these electrical decompositions: the two constituents of the decomposed body are apparently attracted by the

opposite poles of the battery, and, being always evolved at the same poles, have been regarded as each naturally possessed of the opposite electricity. Those bodies which appear at the negative pole are therefore termed electro-positive, whilst those that are evolved at the positive pole are denominated electro-negative bodies; but it is impossible for us to follow up these phenomena further, until we have made ourselves acquainted with the general principles of chemical nomenclature and other matters; we shall therefore refer to them again in a future lesson.

HOW TO OBSERVE.

BY EDWARD PURCELL.

LESSON I.

"The works of the Lord are great, sought out of all them that have pleasure therein."

1. MAN, gifted by his Almighty Creator with glorious faculties of thought, has been placed by Him in the midst of a beautiful and wonderful world, and surrounded by objects which supply abundant exercise for all his powers of body and mind. As an intelligent spectator of the manifold works of God, it is his high privilege and delight to trace the operations of those laws which the Supreme Wisdom has imposed upon nature; and, by a proper exercise of his reason, he rises from ignorant wonder to rational admiration, and becomes not a spectator merely, but an interpreter of His works.

2. It is by the senses that the mind is brought into communication with the external objects upon which it has to exercise its powers. Its knowledge, however, is by no means limited to that which they convey, for it builds upon their scanty information a noble superstructure of science, and, enlightened by Divine revelation as to its duties and responsibilities, applies this science to those great ends of all human knowledge, "the glory of God and the relief of man's estate."

The senses are the mere organs and instruments for collecting facts, which the mind sorts and arranges, and they require to be guided and controlled by the intelligent principle within us. Or it would, perhaps, be more correct to say they are the faithful servants of the mind, which cheerfully do its bidding, though sometimes causing mistakes by blunders and inaccuracies. They bring, it is true, large contributions of knowledge, but require both to be incited to the search for it, and to have an intelligent treasurer ready to receive it.

3. A man may possess all his senses in perfect physical condition, and there may be innumerable objects producing those impressions upon them which each is fitted to receive, without any information being conveyed, or any consciousness even of the existence of the objects affecting the mind. This frequently happens in that condition called reverie, when the attention is not roused into action by our will; and during periods of abstraction or contemplation, when the mind is too much occupied to take the information which the senses are offering to it.

4. Indeed, there are many persons whose senses, however perfect, are of little use to them beyond the preservation of their bodies and the indulgence of their appetites. It is not always those alone who are blind that have no eyes; some allow their faculties to become torpid from want of exercise. But to him who really uses his powers of observation, every summer breeze that fans his cheek comes laden with instruction, the very stones beneath his feet are eloquent, and the whole of nature is one wide-spread book, full of lessons of wisdom, and hymns of praise to Him whose power created and whose goodness sustains all things.

5. Facts are, to use a simile, the alphabet of the book of nature; we must study them carefully before we can expect to read its instructive pages. Now it is this study of facts which is called *observation*. To observe requires attention—that is, an act of the will directing our faculties to give us all the information they can

about some particular subject. The subjects upon which we exercise our observation may be either things external to us, when we must depend on the service of the senses, or mental acts of thought, when we set one class of intellectual faculties to keep watch over the workings of another. We may also observe *relations* as well as *things;* but as the consideration of relations is more an act of the mind than of the senses, we shall defer our remarks upon them to another occasion.

6. To whichever act of the mind we apply the term observation, it means a patient watching—a noting of all the marks and signs which are presented to us, and the order in which they occur. We must, to be true observers, make ourselves servants of nature, and wait with patient attention upon all its movements, not venturing to anticipate what they may be, never deciding beforehand that they must be of any particular character, but watching and recording. This submissive care, which lies at the foundation of all physical knowledge, is beautifully implied in the term astronomer,—a shepherd of the stars, one who watches all their movements, as they wander through the silent fields of night, and from long familiarity can recognise the aspect and tell the place of each individual in his flock.

7. Observation, when it has been for some time practised, becomes a habit, and is then one of the greatest sources of rational enjoyment. For wherever we may be placed there is always something to observe, something to interest, something to prevent that vacuity of mind which causes a languid dissatisfaction, even when it is not, as too often happens, an incentive to vice. The very exercise of our faculties has been beneficently made in itself a pleasure; and as the young of animals delight in the mere muscular effort of bounding across the fields, so the nobler being, man, possesses a never-failing source of happiness in the healthy development of those higher powers with which he is endowed.

8. But if, beyond the mere pleasure derivable from a habit of observation, we wish to arrive at such facts as shall afford a firm foundation for science, we must use many precautions, and pursue a strict and careful method of inquiry. We must *test* our facts before we receive them into the armoury of knowledge. To assist in doing this the following suggestions will be found useful.

9. (1.) In making an observation be careful to examine *the whole* of an object. Try to observe it on every side, and, if you can, look *inside* it. By an old form of our laws, the possession of a landed estate used to be transferred from one person to another by handing to him a twig that grew upon it, or a turf from its soil. Some people think that they can acquire knowledge in the same way; they rest satisfied when they obtain a bit of it. In the legal form referred to, a part was, for convenience, made to represent the whole; but this representative method should never be relied on in acquiring knowledge, lest a mere symbol come to be mistaken for a reality, and we thus cheat ourselves into thinking that we are in possession of truth, when we have only seized on a twig from one of its branches. We must grasp the *whole truth*, or we had better be without any of it, for a part only is certain to mislead.

10. Hastiness of assertion, and inaccuracy of knowledge, spring from the neglect of this precaution. The two disputants about the colour of the shield were each perfectly certain that his opinion was correct—that he could not mistake the evidence of his own eyesight: one saw that the shield, as he looked at it, was gold; the other perceived, with equal clearness, that it was silver; each was prepared to support his honest conviction by force of arms, when a calm spectator suggested that they should turn round the cause of the dispute. Then, with equal astonishment, the angry foes found that they were both right and both wrong. The shield was neither gold nor silver, but each side made of a different metal.

11. So men, looking at the same object or fact from different points of view, often come to opposite conclusions, and dispute with vehement obstinacy; forgetting that each may be partially right, while neither possesses the whole truth. These half views of things have caused the greatest errors in philosophy. No intellectual being, when his interest, prejudices, and passions are not engaged in the question, wilfully loves an untruth; but it very often happens that when the mind is possessed by a *half-truth* which it perceives clearly, it refuses to examine farther, and rather seeks for arguments to support its first impressions, than opens itself to a more enlarged and truthful view. There have been few originators of false philosophy who have not had *some* truth on their side: we should endeavour to arrive at the whole truth before we venture to rest any conclusion upon our observations.

12. It sometimes occurs that, either from its size or inaccessible position, we cannot go round an object and obtain this complete view; but we may be able to obtain trustworthy *evidence* sufficient to give us a knowledge of the parts unexamined, and so come to a just conclusion on the whole. In no case can our observation lead to error if we limit our conclusions to what we have seen. Thus the earth appears to a spectator fixed to one place, to be a limited plain with a circular boundary; and if he asserts that it so *appears* to him, he will be quite correct, although we are well aware that the earth is not a plain, having abundant evidence, as was seen in the section on Physical Geography, to show that it has a spherical surface. The great point is, when we have not seen the whole, to state exactly what we have seen, and allow other observers to complete the examination; and what we have to guard against is a tendency to conclude that the unexamined part is similar to the portion which we have observed, which it may or may not be.

13. Not to rest satisfied with "the coloured surfaces of things," but to examine their inward structure, is, of course, necessary to prevent our making hourly m

takes. The "Dead Sea fruit that grows by that bituminous lake" may appear pleasant to the eye and good for food, while within it is bitter and dry. And, indeed, not merely in the case of actions and conduct, but of inanimate objects also, we should remember the injunction, "Judge not according to the appearance, but judge righteous judgment."

INSTRUCTION.

From heaven descend the drops of dew,
  From heaven the gracious showers,
Earth's winter aspect to renew
  And clothe the spring with flowers.
From heaven the beams of morning flow,
  That melt the gloom of night;
From heaven the evening breezes blow,
  Health, fragrance, and delight.

Like genial dews, like fertile showers,
  The words of wisdom fall,
Awaken man's unconscious powers,
  Strength out of weakness call:
Like morning beams they strike the mind,
  Its loveliness reveal;
And, softer than the evening wind,
  The wounded spirit heal.

As dew and rain, as light and air,
  From heaven Instruction came,
The waste of nature to repair,
  Kindle a sacred flame;
A flame to purify the earth,
  Exalt her sons on high,
And train them for their second birth—
  Their birth beyond the sky.

Albion! on every human soul
  By thee be knowledge shed,
Far as the ocean-waters roll,
  Wide as the shores are spread:
Truth makes thy children free at home;
  Oh! that thy flag, unfurled,
Might shine, where'er thy children roam,
  Truth's banner round the world.

James Montgomery.

LESSON II.

HOW TO OBSERVE—*continued.*

"And he spake of trees, from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall: he spake also of beasts, and of fowl, and of creeping things, and of fishes.

"And there came of all people to hear the wisdom of Solomon, from all kings of the earth, which had heard of his wisdom."

1. (2.) You should observe any object of which you wish to acquire a correct knowledge, at different times, and note the period at which you made each observation.

The changes in the kingdom of nature, which produce such charming variety, supplying food for observation and constant sources of delight, are so incessant, that seasons, days, and even hours and minutes, produce striking differences in the appearances of objects. How different is the aspect of nature in "the leafy month of June," when a rich luxuriance of vegetation clothes the earth with beauty, to that which it presents in the barren, leafless winter. All animate nature participates in the change. The habits and appearances of animals, and their modes of subsistence; the migration and social instincts of birds; the form and development of insect life, all are influenced by the vicissitudes of the year. Should a fact, therefore, come under our notice, we shall find our after-judgment greatly assisted by recording the *time* when it was observed. By a repetition of the observation, whenever it is possible, we may thus be able to ascertain whether the phenomenon was temporary or permanent, and if the former, at what time the change occurs, and whether its recurrence is periodical or not.

2. As a simple illustration of the necessity of this precaution, it may be sufficient to remark, that were any traveller to assert generally that swallows abound in England, or that arctic foxes are white, his information would lead to error, unless he mentioned the period when he observed them: and in the physical

sciences most observations are utterly valueless, unless the time and place are recorded at which the phenomenon happened. The importance of attending to the time at which facts present themselves may be shown by the following instance. The meteors popularly called shooting stars had been frequently observed, and much ignorance and error as to their nature existed even amongst learned men: it was gradually noted that they appeared in greatest numbers at particular periods of the year, and upon this periodical recurrence has been based, what seems to be the true theory of their nature, that they are small bodies, subject to planetary laws, which the earth meets in particular points of its annual course.

3. Independently of the mutability of objects, and the consequent necessity for repeated observations to distinguish the permanent appearances from those which are variable or periodic, there is another reason why we should never rest satisfied with a single examination when further opportunities for inspection are afforded us. The senses, our instruments of observation, are extremely variable in tone and vigour with different conditions of bodily health, and consequently the impressions which they receive are not all equally trustworthy or accurate. The mind, also, under particular influences often gives a bias to the information conveyed: even our feelings of joy or sorrow, pleasure or pain, give a peculiar character to the phenomena surrounding us, and, though they cannot change their character, often alter their appearances. Sometimes we *cannot* observe with accuracy, sometimes we *will not*. The senses are at times incapable of conveying exact information; and at times the mind, from preoccupation or indolence, or the excitement of passion or prejudice, is not in a condition to receive it. We can, to some extent, free our observations from this class of errors by repetition, as astronomers, to secure accuracy, take a mean of several transits to obtain the closest approximation to the true one.

4. (3.) Another suggestion somewhat similar to the preceding, is this:—examine a thing, whenever it is possible, under a variety of circumstances and in proximity to different objects.

The cameleon takes a hue from that of surrounding objects; and in a figurative sense, so far as the mental impression is concerned, the same may be said of everything which we perceive. Our sensations possess a degree of accuracy, relatively, not merely to the state of mind and healthy condition of the organ at the time, but also to the objects upon which they have just previously been engaged. After the eye has been exposed to a vivid light, a moderate illumination will produce the effect of darkness. If you gaze steadily for some time at a strong colour, such as red, and turn your eye upon a white surface, you will perceive a green tinge upon the white. It is supposed to be from this cause that when one of a pair of double stars has a reddish tinge, the other appears to be tinted green. It may be with truth asserted, that when strong colours are next each other we never see either as we should were it alone, or in conjunction with a different hue; and it is probably upon this visual effect that the harmony of colouring depends.

5. Similarly with our feeling of touch, a body that is really warm appears cold to the hand that has just been in contact with a highly-heated surface; and in every case our judgment of heat and cold is modified by the temperature of our own bodies at the time. Again, any moderately even surface will appear smooth to a finger which has just been rubbed along a file; and the same influence of involuntary comparison might be copiously illustrated from the senses of taste, hearing, and smell. In our muscular sensations, also, how differently do we estimate the same amount of exertion at different times; how light does a pound weight appear to the arm that has just lifted half-a-hundred weight; how easy must the use of his war-sword have been to the Roman soldier, who had been exercised with a much heavier

weapon! These instances will be sufficient to show how necessary it is to alter the circumstances under which any object has been examined, in order that we may be able to separate the relative effects resulting from the influences of surrounding objects from those which are really produced by the object itself.

6. (4.) You should always endeavour to ascertain the meaning of the phenomena observed, without ascribing to them greater significancy than they really possess. Above all, you should avoid mingling with a fact your mental conclusion as to its cause.

Should we hear a noise, we are not hastily to assert *some one* is making a noise. The cause of the sound may be the motion of some inanimate object in obedience to physical laws; whether it be so or not is a matter of after investigation. The most injurious errors arise from this habit of referring to some unknown personal agency, sounds, or appearances, whose origin we cannot immediately discover. We are so accustomed to trace human influences in the production of a vast number of effects, that when we observe an action similar to those which human efforts would produce, but in which we can perceive no human agency, we are ready to fancy the interference of some existences similar to man. This, while it encourages indolence in the search for the true cause, and lulls our ignorance into self-satisfaction, is the fruitful source of those popular delusions and superstitions which so often seize hold on the public mind, and sometimes lead even sensible people astray. The ignorant and unthinking person who sees in the twilight a white sheet or wall, is not satisfied with saying or thinking that he has seen something white, but adds to it what he has not seen at all—an imaginary person, and calls it a ghost. If we once allow these mental additions to our observations, there will be no limit to the absurd conclusions at which we may arrive. Thus, in popular superstitions, ghosts are frequently represented as intimating their presence by stamping with heavy boots, slamming doors, moving tables, or making other violent *physical* exertions, actions the most opposed to even our fancies about spiritual existences.

7. The tendency to personify natural occurrences, which I wish here to caution you against, seems to have given its origin to some of the worst follies of heathen mythology. Every breeze that blew was to the superstitious and fanciful Greek the breathing of some Zephyrus or Notus; the glancing lights that played under the woodland shades, were the bounding figures of Dryads and Fauns; the sparkling ripples and gentle murmur of the stream arose from the sporting of water nymphs, or the river was itself a god. A light, a noise, a movement, became to them a being with like passions and feelings to themselves. Thus the Almighty Creator and Sovereign Ruler of the Universe, the great First Cause of all phenomena, was forgotten, and the honour due to Him given to the creations of a diseased fancy. An honest and careful observation of the operations of nature would have been the best safeguard against paganism, for in the visible world, "God left not himself without witness in that he did good, and sent rain from heaven and fruitful seasons, filling our hearts with food and gladness."

8. (5.) To conclude, we should, as a general rule, be *honest* in all our observations; not merely in recording them so as not to deceive others, but in making them, so as not to deceive ourselves. We should endeavour, when examining a fact, to ascertain what it is, not what we wish it to be. We should not view objects through our theories or inclinations; for these, like coloured glass, impart their own hue to everything seen through them. If we thus keep our faculties always ready for use by healthful exercise, and our attention awake to all that is occurring around us; if we use patient care and watchfulness in studying the objects which nature presents to our notice, and examine and record honestly all the information our senses convey; if we receive facts as they *are*, without having our vision tinged by

prejudice, or dulled by apathy, or magnified by fancy, we shall both lay a sure foundation for the establishment of scientific truth, and form a habit of sound observation applicable to any branch of knowledge of which we may be anxious to pursue the investigation. —EDWARD PURCELL.

ADAM'S MORNING HYMN.

THESE are Thy glorious works, Parent of good!
Almighty! Thine this universal frame,
Thus wondrous fair! Thyself how wondrous then!
Unspeakable! who sitt'st above these heavens,
To us invisible, or dimly seen
In these Thy lowliest works; yet these declare
Thy goodness beyond thought, and power divine.
Speak, ye who best can tell, ye sons of light,
Angels; for ye behold Him, and with songs
And choral symphonies, day without night,
Circle His throne rejoicing; ye in heaven.
On earth, join all ye creatures to extol
Him first, Him last, Him midst, and without end.
Fairest of stars, last in the train of night,
If better thou belong not to the dawn,
Sure pledge of day, that crown'st the smiling morn
With thy bright circlet, praise Him in thy sphere
While day arises, that sweet hour of prime.
Thou sun, of this great world both eye and soul,
Acknowledge Him thy greater; sound His praise
In thy eternal course, both when thou climb'st,
And when high noon hast gained, and when thou fall'st.
Moon, that now meet'st the orient sun, now fly'st
With the fixed stars, fixed in their orb that flies:
And ye five other wandering fires, that move
In mystic dance, not without song, resound
His praise, who out of darkness called up light.

* * * * *

His praise, ye winds, that from four quarters blow,
Breathe soft or loud; and wave your tops, ye pines,
With every plant, in sign of worship wave.
Fountains, and ye that warble, as ye flow,
Melodious murmurs, warbling tune his praise.

Join all ye living souls; ye birds
That singing up to heaven-gate ascend,
Bear on your wings and in your notes His
Ye that in waters glide, and ye that walk praise.
The earth, and stately tread, or lowly creep,
Witness if I be silent, morn or even,
To hill or valley, fountain or fresh shade
Made vocal by my song and taught His praise.

MILTON.

Mechanics.

BY EDWARD PURCELL.

LESSON I.

USE OF MACHINERY.

1. EVERY traveller who has visited the gigantic ruins of Baalbec, the pyramids of Egypt, or even our own Stonehenge, has expressed wonder at the means by which the immense masses of stone which appear to have formed these structures were raised to their positions. It is manifest that unaided human hands, however numerous, could not have accomplished the work; and consequently, while the ignorant, by ascribing it to giants, merely confess that they do not know how it was done, the learned set themselves to inquire what *machinery* the constructors used. But it is not only in the case of great physical difficulties overcome that the inquiring mind traces the intervention of machinery; there are many other results which experience prevents our ascribing to the unassisted human hand and muscles; for instance, when great regularity of motion or perfect accuracy of fitting is observed in any work, we are forced to conclude that even the best-trained hand could not move with so continuous a regularity, or finish the parts with such exactitude; so that in these and a multitude of similar instances we are again obliged to refer to *machinery*.

2. Without dwelling longer upon the manner in which some feature of the work done causes the mind

to deduce the prior application of a machine, we may enumerate the following as amongst the most obvious uses of machinery. (1.) It increases human power. (2.) It insures accuracy of fitting. (3.) It gives regularity of motion. (4.) It increases or diminishes velocity. (5.) It gives rapidity and consequent abundance of production. (6.) It enables us to employ usefully comparatively worthless materials; and lastly, it renders possible the application to manufacturing purposes of the mighty forces which nature supplies.

3. (1.) *Increase of human power.*—Machinery, in its widest sense, means any material contrivance used by man in the performance of work. It therefore includes all kinds of tools, as well as machines ordinarily so called, but usage has limited the signification of the word, and excludes from it all mere tools used to assist the hand; the line of distinction, however, between tools and machines cannot be strictly drawn.

4. Now the first mode in which we may consider human power to be enlarged by machinery, is that it enables men to *combine their efforts.* For instance, in raising a heavy weight of a comparatively small size, a sufficient number of men could not take hold of it, so that by increasing the labourers we should really gain no advantage. Only those that could get a grip could do anything, and the number of these is limited by the size of the body. Under these circumstances we can, by the intervention of a rope and pulley, employ any number of men that may be required to perform the work, and by signal, such as a fife or boatswain's whistle or word of command, give unity to their efforts. It is manifest that by the same simple contrivance we *increase the distance* through which the load can be lifted. The length of a man's arm determines the height to which he can without assistance raise a body, and no matter how many persons be employed the space is equally limited unless they make a succession of lifts; but by machinery their efforts may be made continuous, and so the length of lift be indefinitely increased.

5. Machinery increases human power, by enabling us to apply our strength in that direction in which it is most efficient, and which causes least fatigue. Thus a man can pull downwards with much less exertion than he can upwards, because in the former case he assists himself by throwing his own weight upon the strain: indeed, it has been calculated by M. Coulomb that if loads of firewood, or any other substance, have to be carried up stairs, a man who walks up unladen, and then drags up the load by his own weight in descending, can do the work of four men employed in the ordinary way of carrying it on the shoulders.

6. By means of machinery also we can concentrate a continuous exertion into a shorter one of much greater intensity, and so *gain power by an expenditure of time or loss of distance.* This may be illustrated in the common lever, with which a man (fig. 1.) by making an exertion equivalent to that of lifting half a hundredweight through the space of five feet, a work which he *can* do, may raise five hundredweight the height of six inches, a work, which unassisted he *could not* do.

7. Again, machines even of the simplest kind often remove or *diminish opposition* to our efforts. What a wonderful facility of motion is in this way given by the use of rollers and wheels! No one could drag a load of a ton along a road were the mass in contact with the surface, because the friction would be much greater than he could overcome; place wheels or rollers (fig. 2.) under the weight, so as to diminish the friction, and it is

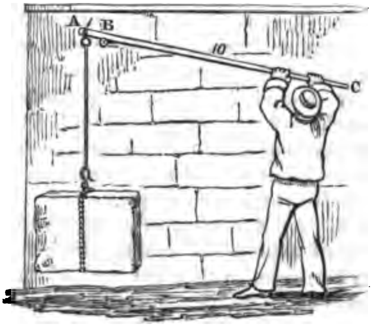


Fig. 1.

easily moved. This simple application of rollers increases the effective result of our exertions more than twentyfold; for it has been found that to draw a block of stone along the roughly-chiselled floor of a quarry requires an exertion equal to nearly two-thirds of its weight, with rollers on the same floor to one thirty-secondth, while on rollers between wood one-fortieth is sufficient. A somewhat similar removal of impediments is produced by the inclined plane, which diminishes the opposition of gravity to our exertions in lifting. A gradually ascending mound of earth would have enabled our British ancestors to draw up to its place the heaviest block at Stonehenge, and the removal of the mound after it had served its purpose sufficient to destroy all trace of the means employed.

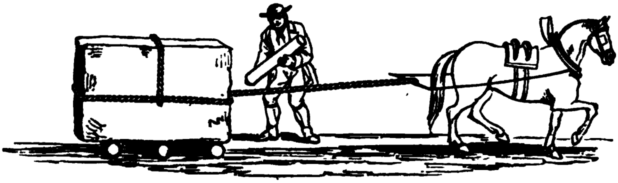


Fig. 2.

8. By thus facilitating co-operation—making efforts continuous instead of being limited to a narrow space—concentrating a continued exertion into a single effort, and removing or lessening impediments to motion—machinery has enabled mankind to accomplish greater works than their natural powers could ever have effected, and to raise those monuments of human energy which survive the lapse of ages.

9. (2.) *Accuracy of construction.*—Whenever a number of articles of exactly the same form and size have to be made, so that any one of them indifferently shall serve a particular purpose, or whenever one portion is required precisely to fit another, the whole value of the manufacture must depend on the accuracy with which the parts are formed. The first of these may be

illustrated in the casting of rifle bullets or cannon balls, the second in fitting a nut to a screw. Now the human hand, admirable as it is in its flexibility and obedience to the mind, cannot even with tools give the steadiness of exertion necessary to produce perfect similarity and accuracy in the articles it forms. Let the most skilful workman endeavour to form a simple round bar of timber or iron, and when it is examined, inequalities are sure to be found; in some places it will err from the circular, and in others be of unequal diameters: in a lathe a similar rod can be turned without difficulty and with perfect regularity. In the same manner no two hand-made articles will ever be found exactly alike, while those that come from a mould cannot be distinguished one from the other.

10. Again, in fitting parts together, such as a screw working in its nut, a piston in its cylinder, &c., precision of workmanship is absolutely essential to a satisfactory result, and in these cases machinery cuts the parts for us with infallible accuracy. In fact, it cannot go astray, the cutter once fixed in its position must move as the rigid metal directs it; there is, as in the case of a workman, no moment of inattention, no inequality of pressure, no slip of the hand to produce irregularities. The great improvement in accuracy due to the employment of machines in the construction of machinery, is shown in the history of the steam-engine. After Watt made his glorious discoveries, and commenced manufacturing engines near Birmingham, the greatest practical difficulty he experienced was in procuring workmen sufficiently skilful to make a hollow cylinder so perfect, and a piston so well adapted to it, that one should move steam-tight in the other. Packings of hemp and oil had to be used; afterwards metallic packing was substituted, and now by the application of machinery the cylinder is cut so uniformly, and the piston so accurately fitted with metal springs, that the necessary tightness is easily secured and maintained.

LESSON II.

USE OF MACHINERY—*continued.*

1. (3.) ***Regularity of motion.***—It is chiefly in our modes of measuring time that we derive the benefit of this characteristic of machinery. The steady swing of the pendulums (fig. 3) of our clocks, going on day and night with the same invariable intervals, and marking for us the progress of the hours, is a beautiful result of the regularity with which machinery can be made to act. No human hand governed by the mind could, for any length of time, continue the same steadiness of action; even the musician, with his practised estimate of intervals, has of late years called in machinery to his aid, and counts his time by the metronome. But it is in the chronometer that the regularity of action of a machine is shown in its greatest perfection. Day after day, month after month, through heat and cold, at rest or in motion, the vibration of the well-constructed balance goes on without a second's irregularity.

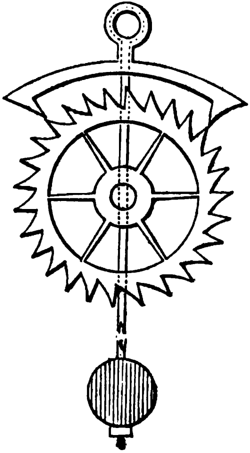


Fig. 3.

2. Steadiness of rate in machines, not constructed solely for the purpose of securing it, as are the clock and watch, is of very great importance, and is attained by a number of contrivances such as the *governor* of the steam-engine, which is also capable of being applied to any other machine. A *fly* or *vane* is frequently employed, as in clocks to regulate the striking, in musical boxes to fix the rapidity, &c.; as the machinery works the vane is driven round, and its flat surface,

coming against the air, checks the motion when it would become too fast. The large heavy *fly-wheel* of engines serves the same purpose of giving steadiness of motion.

3. (4.) *Increase and decrease of velocity.*—Without dwelling upon the fact that the rapidity of motion of the human muscles is limited, from which it results that high velocities cannot be attained at all without the assistance of some machine, we shall point out a few instances in which great advantage is secured by a mere alteration in velocity. In the first place, in many mechanical occupations the labour arises not so much from the resistance to be overcome as from the exertion of moving our own limbs frequently—a rapid motion of the arm itself, though nothing be moved by it, becoming after a time excessively fatiguing; now, if we can greatly diminish the number of times that it is necessary to move the limb, even though a slightly-increased exertion be required in the slow movement, we shall materially lessen the fatigue. There are, in practice, two very simple modes by which this can be done; one is the common *multiplying wheel*, and the other the *treadle*. In the first (fig. 4) a large and a small wheel are connected by a band passing over their circumferences; motion is then given to the larger wheel, and the other is moved with as much greater velocity as its size is less than the larger. Thus, if the circumference of

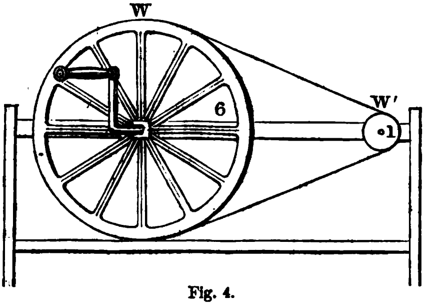


Fig. 4.

w′ be a sixth part of that of w, every time w is turned once by the handle w′ will make six revolutions. The treadle (fig. 5) is worked by the foot, and as it thus leaves the hands of the workman at liberty, it is used for a variety of purposes, such as turning, sharpening cutlery, &c. The heel rests upon the ground, and a comparatively slow motion of the foot is sufficient to give great rapidity of rotation to the materials to be operated upon.

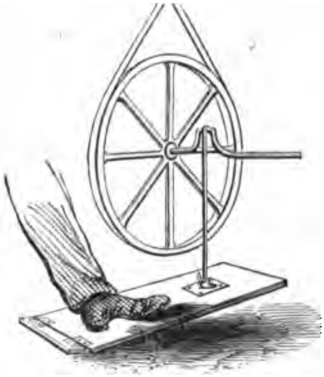


Fig. 5.

4. Let us now consider a simple instance in which these means of increasing velocity effect a great saving of time and labour. In winding up any material, such as thread or cotton, on reels, how tired would the hand get, and how very few could be completed in a day! By the use of a treadle twenty or thirty would be made up at once with very little fatigue, and in a very short time.

4. We have seen that whenever we diminish the *number* of movements required to be made by the muscles, we, to a great degree, lessen our fatigue. Now this is done by several kinds of tools and machinery, which enable us, in one movement, to effect a number of operations. Thus, if a piece of metal has to be measured into lengths, cut and bent, a peculiar form given to the shears enables us to do all these by one action, and a number of other instances of a similar kind might be adduced. There is one very beautiful effect of machinery, which may be mentioned under the head of change of velocity, and that is, it enables us by a short exertion to lay up a reserve of force, which shall

be slowly given off, as it is required, for a length of time. The daily act of winding a watch, or drawing up the weight of a clock, affords an admirable illustration of this; a few seconds expended in turning the key keeps the machinery going twenty-four hours, without any further interference on our parts.

5. (5.) *Abundance of production.*—Owing in a great measure to the regularity and precision of its action, when once it has been set to work, machinery can execute the operations it is constructed to perform, with such ease and rapidity, that the production of useful articles is amazingly increased, and the cost so diminished, that the benefits of its application are extended to all. Illustrations of the increase of comfort, thus obtained for mankind by the use of machinery, are so numerous that it becomes difficult to select one from amongst them. Perhaps the condition and growth of the cotton manufacture, though obvious, affords as striking an example as any that could be brought forward. By the old hand-loom—itself a machine, though of limited power—the quantity of cotton cloth made even by a good workman in a day was small, and the cost consequently considerable; now the whole manufacture is carried on by machinery, the price has fallen, and comfort has been spread amongst thousands, out of whose reach it was by the highness of former prices. If we trace any of our great articles of production we shall find a similar progress; abundance springing up, and prices falling as machinery is applied to an increased extent in the manufacture.

6. (6.) *Employment of apparently worthless substances.*—So long as a workman was confined to the exertions of his own hands, even assisted by tools, he would naturally select for the exhibition of his skill such substances as afforded greatest facilities for manipulation, and whose intrinsic value bore some proportion to the labour and care bestowed on their manufacture. He would not waste his time, or risk the success of his exertions by endeavouring to operate upon inferior

materials. Waste of material, also, in a great many instances, was of less importance than the time it would take to avoid it, especially in those manufactures in which the value of the raw material was small, compared with the selling price of the manufactured article. Hence many substances, capable of useful applications in the arts, were altogether neglected, and of those that were used much was wasted in the process. But as soon as machinery supplied a cheap mode of working, many of these apparently valueless substances became converted into useful materials, and formed the basis of new forms of human industry. The application of chemistry to manufacture supplies the most striking instances of this conversion of worthless into valuable substances; but machinery has many triumphs of a similar kind. Thus, from common oyster-shells are formed iridescent buttons for gentlemen's vests; common bone is worked into combs, and shaped into handles of umbrellas; the refuse of the cotton, which is unfit for the manufacturer's purposes, is converted into the finest paper; the old saucepans which are collected about our streets are cut into slips, punched, and varnished for the use of the trunk-maker.

7. Machinery not only supplies a means of rendering useful what would otherwise be wasted, but also enables us to *avoid* waste by the accuracy with which we can suit our materials to the work to be done, and the directness with which we can accomplish our objects. Thus, to obtain a plank of wood from a tree, with an adze or hatchet, we should cut away and waste a great portion of the trunk, while the saw divides it into planks with comparatively little loss; and when valuable timber is cut into sheets for veneering, the circular saws used have very thin blades.

8. *Application of natural forces.*—In the remarks hitherto made, we have considered machinery as aiding *human strength;* but were this our only source of force, even with the best contrivances for its application, we should fall far short of those wonderful mechanical achievements which we every day witness. For it must

be borne in mind that *no machinery can create force*—it only enables us to apply, in the most efficient manner, those forces which are at our command. The rigid metal has no power of motion in itself, it can only deliver in a modified form, and not without loss in transmission, whatever impulse has been impressed upon it. Great advantages can, as we have seen, be derived from it, even in this limited application; but it is by enabling us to subdue to our service the giant forces of nature that machinery confers inestimable benefits upon mankind. The running stream, the wind, the expansive force of steam, have all been made subservient to human industry; and, by the intervention of machinery, rendered obedient servants of human reason. A source of labour, greater than all human strength combined, has thus been placed at our command, the untiring powers of nature have relieved human sinews from much of the hard drudgery of toil, and man has become not so much the labourer as the director of labour. In the following lesson we shall consider the various extraneous sources whence energy is imparted to machinery.

LABOUR.

Heart of the people! working men!
  Marrow and nerve of human powers;
Who on your sturdy backs sustain
  Through streaming time this world of ours;
Hold by that title which proclaims
  That ye are undismayed and strong,
Accomplishing whatever aims
  May to the sons of earth belong.

Yet not on ye alone depend
  The offices, or burthens fall;
Labour for some or other end
  Is lord and master of us all.
The high-born youth from downy bed
  Must meet the morn with horse and hound;
While industry for daily bread
  Pursues afresh his wonted round.

And he who still and silent sits
  In closed room or shady nook,
And seems to nurse his idle wits
  With folded arms or open book:—
To things now working in that mind,
  Your children's children well may owe
Blessings that hope has ne'er defined
  Till from his busy thoughts they flow.

Thus all must work with head or hand,
  For self or others, good or ill;
Life is ordained to bear, like land,
  Some fruit, be fallow as it will:
Evil has force itself to sow
  Where we deny the healthy seed,—
And all our choice is this, to grow
  Pasture and grain, or noisome weed.

Then in content possess your hearts,
  Unenvious of each other's lot,—
For those which seem the easiest parts
  Have travail which we reckon not:
And he is bravest, happiest, best,
  Who, from the task within his span,
Earns for himself his evening rest
  And an increase of food for man.

R. M. MILNES.

LESSON III.

PRIME MOVERS.

1. THE human hand is by its wonderful flexibility beautifully adapted to be the agent of the mind in forming and using material aids to assist our bodily powers; and the use of some contrivances for this purpose is characteristic of man in every stage of society. The rudest savage points the stake, and hollows out the canoe with fire, or sharpens a stone to aid in separating substances, while in no other animal do we find this borrowing of assistance from implements or weapons—each is limited to the natural powers of its own body for

accomplishing all that it desires. The instruments used by men are of course limited by the extent of their knowledge: at first the most obvious aids are employed, but as an acquaintance with the natural properties of substances increases, the field of selection becomes wider, until at length the most subtle powers of nature are applied by man's reason to compensate for the comparative feebleness of his animal frame.

Indeed were it not that man can, by the exercise of his mental faculties, thus fortify his weakness against the physical difficulties with which he has to contend, his life would be one of misery, and instead of being the ruler he would become the prey of stronger and better-armed animals. Without natural covering to protect him against the vicissitudes of the weather, inferior in bodily strength to many brutes, and not furnished with natural weapons, such as the claws and horns of quadrupeds, his reason alone makes him the best-protected, the best-armed, and the best-supplied creature upon the earth.

2. Not merely in matters which require skill in construction, but in the mere application of strength—in the force that he can exert—mechanical contrivances make him the wielder of an enormous power, such as no combinations of mere animal strength could withstand. No genii of fairy tale could effect more for us than do air and water and steam, when trained into obedience to our wishes. It is in this sense that "human knowledge and power have the same effects;" we cannot create the animal that does our work, but we can subdue it to our use; we cannot cause the winds to blow, or the waters to run, yet knowing the laws by which their motions are governed, we can so intelligently place before them the work to be done, that we make them grind our corn, or drive our ships across the ocean; what heat is we know not, still having become acquainted with its expansive energy, we can make its enormous force subservient to our will in performing astounding feats of strength, or executing the most

delicate workmanship. We thus, by patient attention to nature's laws, become masters of nature's forces, either for our protection or our use, and reason shows its superiority over inanimate force, as well as over brute energy.

3. If we view any piece of mechanism, though it be the most complicated that human ingenuity has devised, we can on a careful examination of its action, trace the motion of all its parts to some first source. Thus if we examine a watch, (fig. 1,) we can trace the motion of the hands H, to that of certain wheels, and from these again to others, until we arrive at the barrel B, within which the spring is contained; through all the parts of a steam-engine we can trace up the motion to the piston, &c. This first motion, to which all the others can be traced, results from some force implanted in nature, which in mechanics is termed a *prime mover.* All the rest of the machinery is employed only to direct this force in the work it has to do, and control it in its action. It is in fact to give to the blind, unreasoning power, some of our intelligence. Now although the discovery in nature of new motive agents may vastly increase the powers under human control, enormous as these already are, the number of prime movers at present in use is comparatively limited, and may be enumerated in the following order—muscular strength, gravity, elasticity of springs, wind, water, and steam.

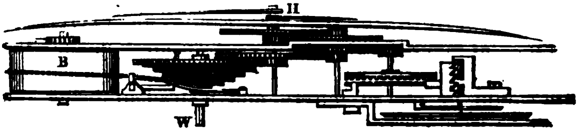


Fig. 1.

4. MUSCULAR STRENGTH.—This is the most obvious and simple of all the prime movers; we exert our muscles before we have learned what work and labour are, and numbers must depend on muscular exertion for

subsistence during a great portion of their lives. The labourer that tills the soil, the bricklayer and carpenter that construct our houses, make use of that vigour of muscle which the Almighty has implanted in their limbs as the first requisite for subduing the earth—the most valuable and readiest servant of man's reason and will. It is this readiness of obedience which makes manual labour indispensable in a great variety of occupations. Whenever different kinds of work have to be done, or the amount and direction of exertions require to be frequently changed, no machine could shift and alter for us with sufficient rapidity to make its employment advantageous; hence much as many of our manufacturing processes have been simplified, there is still a vast amount of irregular work for the human muscles to accomplish.

5. Previous to entering upon the consideration of the comparative value of the different kinds of motive force in the accomplishment of work, it is necessary to fix upon some *standard* of measurement, by reference to which we can estimate the results arrived at by each. Now the simplest standard we can assume must include two things—the resistance to be overcome in order to give motion, and the distance or length through which the action is continued; in other words, *the resistance multiplied by the distance* equals the work done whenever the resistance is *constant*. In lifting a weight, for instance, the resistance is the number of pounds to be raised, and if we multiply this by the number of feet to which it is raised, the product will represent the amount of work done. Thus 10 *lbs.* raised to a height of 5 feet gives 5 × 10 = 50*f. lbs.* Now if we take as a minimum amount of work that of raising one pound to the height of one foot, and call this the *unit of work*, the product 50*f. lbs.* will represent 50 of these units, and in future we shall use the term units of work, or the initials U. W. for the product of the feet and the pounds.

6. What is true in the case of lifting weights extends

to *all kinds of mechanical work*, because resistance always can be and is *estimated in pounds*. Thus if it be required to drag a carriage along a road or up an inclined plane, the weight which, suspended from a cord passing over a roller at the end, is just sufficient to cause motion, may be taken as the resistance to be overcome.

7. It is upon this principle that *dynamometers*, or measurers of strength, are constructed. The most perfect dynamometer for mechanical purposes is that used by Morin in his important researches upon friction, and the work of animals and machines. It consists of two steel springs from ten to twenty inches in length and of equal strength united at their extremities. They become thicker towards the centre than at the ends in order to ensure an equal resistance through the whole length. The centre, N, of one of these springs is connected with the resistance to be overcome, and the centre of the other, M, with the force applied; the separation which results between the two springs measures the effort made by the force. If before the application of such an instrument a known weight be suspended from the centre of one of the springs placed horizontally, and the separation thus caused be measured, a scale may be prepared which will show the weight or force corresponding to each degree of separation. To make the instrument more perfect for efforts varying in amount, such as those of a horse drawing a load, a means of self-registration is provided in the little cylinders marked E and F.

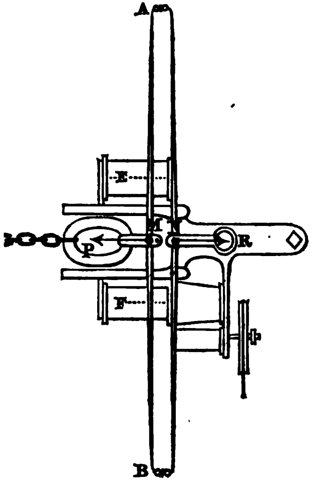


Fig. 2.

8. The mechanical effect produced by a revolving shaft may also be measured by weights. Instruments for this purpose are called friction-brakes. The simplest perhaps is that shown in fig. 3. An iron ring is fastened tightly at B, round the shaft to be examined, and on to this a lever, A, is fixed by a circular fork which fits into fastenings placed on the ring at D and E. To the end of the lever, weights are attached sufficient to keep the lever horizontal during the revolution of the shaft; and from the amount of weight required the work given off at the surface of the shaft is deduced.

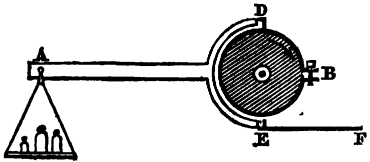


Fig. 3.

9. Having now ascertained the manner in which work is estimated, we shall proceed to consider the relative value of some of the motive agents. In the case, however, of the muscular efforts of men it is difficult to arrive at any correct general result, owing to the varieties of work at which they may be employed, and differences in the strength, good will, and skill of the individuals experimented on. Still an average has been taken of the effort exerted in different kinds of labour, and we may usefully introduce a few of the results. Thus it has been ascertained that a man can walk unburdened for 10 hours a day at the rate of 4¾ feet per second; supposing his weight to be 140 lbs., in this case we get as the day's labour, 140 × 4·75 × 10 × 60 × 60 = 23,940,000 U.W. If he carry a weight of 85½ lbs. he can only walk during 7 hours at the rate of 2⅖ feet per second, and his day's work, without considering his own weight is 85·5 × 2·4 × 7 × 60 × 60 = 5,171,000 U.W. A man unburdened can ascend a flight of steps during a day of 8 hours at a velocity of 0·48 feet per second in a vertical direction, therefore assuming his weight as before, his day's work amounts

to $140 \times 0{\cdot}48 \times {\cdot}8 \times 60 \times 60 = 1{,}935{,}000$ U.W., so that a man can go over 12½ times the space horizontally that he can vertically.

10. The best means of applying the power of men is the windlass represented in fig. 4. The form here shown is called the winch, and the shape of the handle gives the labourer the advantage of a continuous hold throughout its revolution. In order that the most work may be done by a labourer with this machine, the length of the crank or vertical part of the handle must not be more than from 16 to 18 inches, according to the length of his arm; and the support on which it turns not more than 36 to 39 inches above the floor on which he stands for a man of an average height. As a man can work with less fatigue pushing than lifting, the effort required to be made is not equal throughout the revolution of the handle, and in double-handled winches the handle-cranks are turned opposite ways to equalize the efforts of the men, and enable them to assist each other. The day's work of a man heaving at the winch has been found to be 1,175,040 U. W., with a mean effort of 17lbs., a mean velocity of 2·4 feet, and a working day of 8 hours.

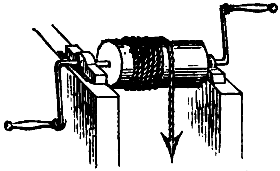


Fig. 4.

11. Animal Strength.—The amount of work performed by an animal not only depends on its condition as to health and strength, but also upon the effort required of it, the speed, and the length of day's work—all these require to be properly regulated, in order to obtain the maximum effect. It has been ascertained that animals produce a greater effect when they work with variable efforts and speed than when these are constant for the day, and pauses in the work make the accomplishment of it less fatiguing. The main point to be attended to in the employment of animals is the

day's work; if this be compared with the daily cost of food, and the interest of the capital invested in them, we can arrive at a pecuniary value of the various animal powers. Animals such as horses, mules, asses, oxen, &c., are principally employed in carrying burdens or dragging weights, either in wheeled carriages, or ploughs, harrows, and other implements of husbandry; they are also, though less frequently, employed to give revolution to a shaft in different kinds of mills and agricultural operations. A horse, it has been found, can carry 256lbs., for ten hours daily, walking 3½ feet per second, so that its day's work, calculated as we have done that of a man, would amount to 32,256,000 U. W. or six times as much as a man's at the same kind of work. If the weight be reduced to 171 lbs., he will trot at 7 feet per second for 7 hours daily, but the work done will be only 30,164,400 U. W. daily. When a horse is applied to turn a shaft, it is usually by a contrivance called a *whim-gin*, shown in fig. 5; the horses are harnessed at H H, and as they move, give revolution to the shaft which rests upon a pivot at O. The ordinary day's work in this machine, the horse going at a walk, has been estimated at 7,984,400 U. W.

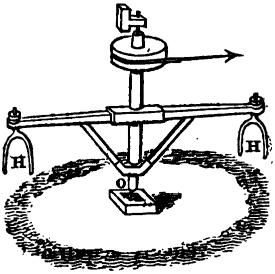


Fig. 5.

12. We see from the above facts, that the units of work done by a horse in a given time, vary considerably with the kind of work on which it is employed, and the velocity at which it is driven. From experiments made some years ago, however, it was concluded that a horse was capable of effecting 33,000 U. W. per minute, and this was taken as the standard for estimating all the more powerful prime movers such as steam and water. The term *horse-power*, derived from this, still continues

in use, though no longer with any reference to the animal, but meaning a force that will yield this fixed number (33,000) of units of work per minute. To find, therefore, the horse-power of any machine, we divide its estimated work per minute by 33,000. The number of horse-powers of an engine on the other hand multiplied by 33,000 will give its units of work per minute.

13. It must be borne in mind that the units of work thus calculated merely show the *quantity* of work done, without telling us anything as to the intensity of the force or violence of the effort required. If we want to ascertain this, we must farther take into account the *time* in which a certain amount of work is accomplished, since the greatest force is that which effects a given quantity of work in the *least* time.

LESSON IV.

PRIME MOVERS—*continued.*

1. Gravity is used to give motion to clocks by the regulated descent of a weight; and large hammers, lifted by some means and let suddenly fall, are used in driving piles, beating out iron, &c. In the latter case advantage is taken of the fact that the velocity of a falling body increases with the distance, so that the momentum or weight, multiplied by the velocity, increases also. The velocity acquired by a body falling from a height of 16 feet is somewhat greater than 32 feet per second, and generally the velocity acquired in falling from any height may be found by the formula $v^2 = 64\,s$: this, multiplied by the weight in pounds, gives the force of impact. In the clock (fig. 6) it is the weight, W, that gives motion by turning the barrel on which the string that supports it is wound; the pendulum, P, and scapement, also shown in the figure, serve only to make the descent regular and gradual. When we *wind up* a clock, we draw the weight to the highest point by coiling all the cord round the barrel, and we say a clock has *gone*

down when it stops, because then the weight has got as low as the length of cord will permit.

2. Springs have a variety of forms, and are chiefly employed as prime movers in small and delicate machines where no great force is required. Iron, when converted into a peculiar sort of steel, has great elasticity, so that if bent out of its shape within certain limits, it will endeavour violently to recover it, and it is this effort which the steel makes to resume its original form that is used as a motive force. Springs may be manufactured in any shape required, and so we have spring-locks, spring-guns, &c., and, as we have already seen, spring dynamometers.

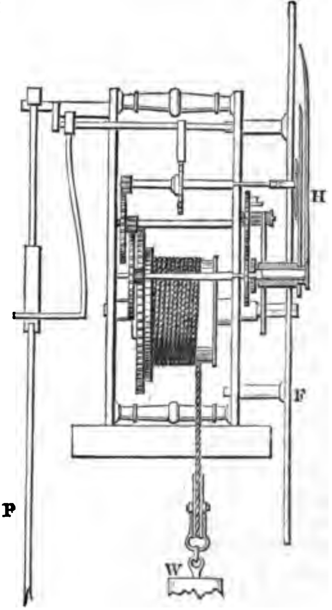


Fig. 6.

It will be sufficient here to describe the spring used to give motion to watches, musical boxes, and similar delicate machines. This (fig. 7) is made flat and long like a ribbon, coiled up in a circular box which turns on a little shaft through its centre; to the shaft one end of the spring is fixed, and the other to the circumference of the box. If now we turn the box round in the direc-

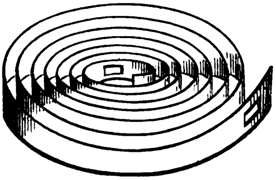


Fig. 7.

tion marked by the arrow, it is manifest that we must coil the spring up more tightly, and in its efforts to free itself it will turn the box back again, and this, by an ingenious contrivance, is made to move all the wheels of the watch. When we *wind* a watch we pull the spring box or barrel, B (fig. 8), round by winding up the chain which is round it, on the fuse, C; in the effort to free itself the spring pulls this chain back again, and in so doing turns the fuse and keeps the watch going. So that what we do in a minute when winding the watch, it takes the spring twenty-four hours to *undo*, and then we prepare its work for it again. The spring thus serving as a reservoir of force, from which the machinery draws off a slow and regular supply.

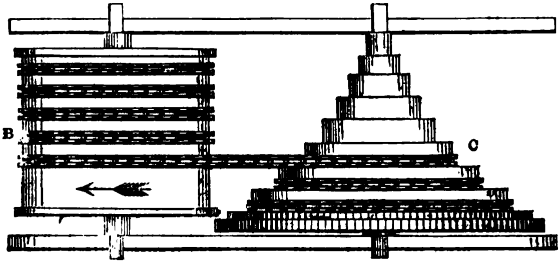


Fig. 8.

3. Wind.—The fickle winds which blow with such uncertainty of force and direction, have been trained into steady and obedient workmen. They drive our ships in any direction we require across the ocean, and, like patient drudges, grind the corn in our mills—the punishment inflicted by the Romans upon refractory slaves. Windmills are driven by the action of the wind upon a *sail-wheel*, the general arrangement of which is as follows:—Four arms are fixed at right angles to an axle placed in a nearly horizontal direction, and on these arms the sails are extended by cross-bars. The arms may be of any length that the height

and strength of the building will admit, but are usually about 30 feet. The cross bars pass through the arms at intervals of from 15 to 18 inches, but project much less on the wind side than on the other; the narrower ends are covered by the ***wind-board***, and the covering of the longer ends is called the ***wind-door***, or the ***sail***, when a sail-cloth covering is used. The sails are generally made *flat*, and then the bars have all an inclination of from 12° to 18° to the plane in which the arms revolve. To give strength to the sails the ends of the bars are connected by ***uplongs***. All these parts can be traced in fig. 9. The shaft generally dips from 5° to 15° from the horizon, in order to keep the sails in their revolution clear of the building, and also because wind has a slightly downward direction. The neck of the axle rests upon a bearing, and the extremity turns in a pivot. On the axle is a *spur-wheel*, which transmits the motion to the work to be done.

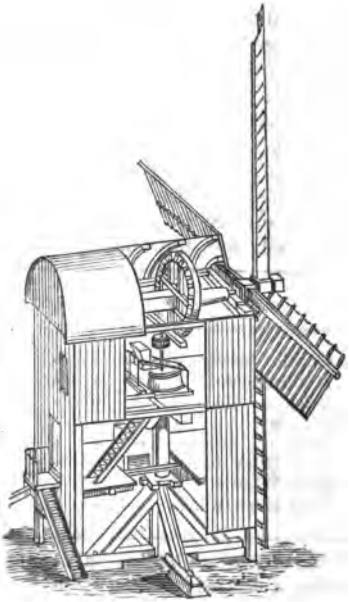


Fig. 9.

4. As the wind is variable in its direction, it is necessary to provide some means of turning the sails so as to direct their surface to the wind. This is done in mills similar to the one represented by turning *the whole*

fabric round on a pivot by means of a long arm or lever. These are called *post-mills*, and are of course constructed of wood. In mills where the tower or main building is fixed, the cap containing the axle and sails alone turns, and the motion is transmitted by a bevelled wheel to another fixed on a vertical shaft called the king post. These mills are called *tower-mills.*

The direction of the wind is ascertained by the *vane* or weather-cock, with which we are all familiar. It turns on a pivot and presents to the wind the end which offers to it the least resistance. The force or pressure of the wind is estimated by an *anemometer.* This instrument is made in various ways: either the *velocity* is determined by the number of revolutions given to a small wheel, or the *pressure* is ascertained by the column of fluid it sustains, or the pressure upon a given surface is ascertained directly. The following table will show the velocity and impulsive force of winds.

	Velocity per second.	Impulsive force per square foot.
	Feet.	
Gentle breeze - - - - -	10	0·2455
Moderate do. - - - -	15	0·5524
Brisk do. - - - -	20	0·982
A Gale - - - - - -	25	1·534
Brisk do. - - - -	30	2·209
Very Brisk do. - - - -	35	3·007
High Wind - - - - -	45	4·971
Very High Wind - - -	50	6·1375

A breeze of 10 feet is not in general sufficient to drive a loaded windmill, and one above 35 feet is dangerous except with diminished sails.

5. The general principle on which motion is produced by the action of the wind on the sails can be easily understood, although the special calculation for each particular size, form, and position is a problem of some difficulty. Were the sails flat to the wind, that is, at right angles to its direction, no motion would result

from the impact however violent; we should only by spreading them cause an increased pressure against the axle and its supports. But we have seen that their surfaces are sloped away at a certain angle, and the force of the wind received on these inclined surfaces is divided into two parts; one, and this a large portion, is, indeed, wasted against the supports, but the other portion acts as though it came from the side, and so drives the arms round.

A windmill of four plane sails, 24 feet in length and increasing from 6 to 9 feet in width, inclined at an angle of 15°, with the wind at 20 feet per second and making 16 revolutions per minute, gives a theoretical effect equal to 4·34 H.P. This effect is practically reduced by the friction of the different parts of the machinery.

6. WATER.—Water supplies a mechanical force, either by its *weight* or by its *impetus* when in motion, or by *both combined*. We have already spoken of gravity as a mechanical power, and water when its weight alone is used might have been considered under the same head; it possesses, however, even when thus employed, certain advantages from its fluid properties which entitle it to separate consideration.

It has been found that the weight of a cubic foot of water may for practical purposes be estimated at 62·5 lbs. avoirdupois, though of course it varies slightly with changes of temperature and purity. Every cubic foot of water, therefore, that rests upon a surface represents, considered as a mere weight, one equal to 62·5 lbs. Let us now see how we can apply this fact. Suppose a large barrel be made with chambers round its circumference to hold water, and supported so as to turn freely on a bar passing along its centre. If water be then poured upon it so as to fill the chambers at one side and not those at the other, we shall soon find that the loaded side sinks under the weight placed upon it, and if we keep up the supply of water the barrel must revolve. This contrivance, shown at fig. 10, represents what is called an *overshot* wheel, such as is generally used in mills. It is manifest from the description that any other kind of weights hung on at one side would cause motion, but the advantage that water affords is that a steady supply of weights is kept up by it as it flows, and they remove themselves out of the way when their work is done.

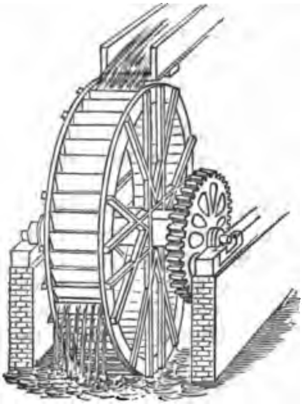


Fig. 10.

To be able to employ this kind of wheel, we must have a *fall* rather greater than the diameter of our wheel; that is, we must lead water in a *mill-stream* from some source higher than the mill, and keep up its level until we have brought it over the wheel it is to work. On this account overshot wheels are never seen in a flat country, from the want of an elevated source.

7. Whenever water is in motion, as in the case of a stream or river, we can cause it to impinge against floats or projecting boards, placed round the circumference of a cylinder balanced on its centre, and so obtain revolution by the force with which it strikes. As each board is driven out of the way by the force of the moving water, another comes into its place to receive the impulse in its turn, and so the motion of the cylinder is continued. This is termed the *under-shot-wheel*, and is represented in fig. 11. The water previous to reaching

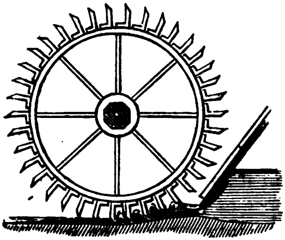


Fig. 11.

the wheel is usually confined within a channel as broad as the cylinder is long, so that all of it must come against the floats; and whenever it is practicable, the velocity is increased by a sudden inclination given to its bed. Sometimes the wheel is placed on its side, and the water drives it round horizontally, which would be, of course, impossible in an overshot wheel. We may consider the action of the water in this arrangement as a succession of *blows*, just as the other might be represented by a succession of *weights*.

8. In many mill-wheels, these two modes of action are combined; that is, the water is delivered upon the wheel with considerable velocity, so as to drive by its impulse, and then, being confined between the barrel upon which the floats are set, and the bed of the wheel, it continues to press downwards by its weight until it escapes at the bottom. This arrangement, represented in fig. 12, is called a *breast-wheel*, from the point at which the water first strikes it.

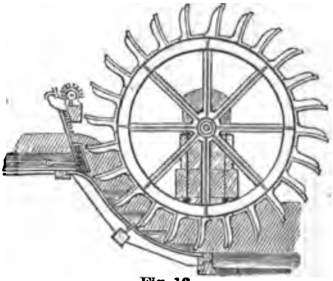


Fig. 12.

9. The principal elements in determining the work of a mill-wheel are (1.) the diameter of the wheel which determines the leverage at which the force acts; (2.) the weight of the water, and (3.) its velocity. Now of these the size of the wheel is a matter of measurement; the velocity of a stream can be ascertained by the length of silk line a float winds off a reel in a given time, or by the number of revolutions caused in a little wheel held across its course; and from this velocity, and the extent of a vertical section of the bed, the quantity, and, therefore, weight of water, may be ascertained. Thus, if at a particular spot, the section of a stream measures six square feet, and the velocity at the same

point be four feet per second, then $6 \times 4 \times 62{\cdot}5 =$ 1,500 lbs., gives the weight of the water which passes every second. If we wish to obtain the supply in gallons, we may roughly estimate about six gallons to a cubic foot, and the weight of a gallon to be about 10 lbs.

10. The reaction of water against the side of a vessel from which it flows, is also a source of considerable mechanical power. This application of water pressure, which was first practically exhibited in Barker's mill, has since been modified and applied in a great variety of forms in machines called *turbines*. It will be sufficient for our present purpose to give a short description of Barker's mill, as the *principle* which this involves is the same as that of all similar machines. A hollow cylinder (fig. 13) is placed vertically, by means of a shaft passing through its length; this shaft turns on a pivot below and in a collar above, and carries a cogged wheel to communicate motion to the machinery on which it is employed; attached to the bottom of the cylinder is a horizontal arm, also hollow, but closed at each end, and having apertures in the side, near each extremity. These apertures are at opposite sides of the arm, and as the water, which is admitted into the cylinder at the top, flows out through each, it pushes the arm backwards, and causes the shaft to revolve.

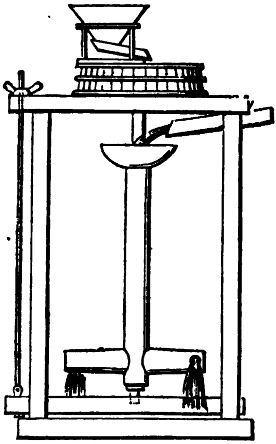


Fig. 13.

11. Steam.—This is by far the most energetic prime mover under the control of man. In our own country especially, its untiring and resistless strength performs the labour of millions of men or horses, bringing wealth

to its employer, and increased comforts to the entire human race. That beautiful contrivance, the Steam Engine, which gives a body and limbs to the subtle energy of heat, will be fully described in another part of the series; it must suffice at present to lay down a few general principles. When we add a certain amount of heat to water, an enormous expansion takes place, and the liquid spreads itself out into an invisible vapour called *steam*. If the vessel containing the liquid be open, it passes gradually into the atmosphere and regains its original form of water, but if it be confined in a close vessel, in the effort it makes to expand it presses against the walls of its prison, and every obstacle in its way. This pressure we use as a mechanical agent. A cubic inch of water spreads out into about a cubic foot (1728 inches) of steam, and in doing so exerts a force nearly sufficient to raise a ton weight to a height of one foot. Nor does its utility end here, for, by causing the vapour to shrink again into its little inch of water, we obtain a vacuum against which the atmospheric pressure of 15 lbs. per square inch acting, gives another effort of the same amount. We thus find that a cubic inch of water made into steam, and then condensed into water, gives force sufficient to raise two tons a foot in height: this, therefore, is the *theoretic* work of steam, from which, however, a large deduction must be made for imperfections in our mode of applying it.

We must always recollect, that the work of a prime mover applied to machinery, is always less than it is capable of doing were it not trammelled by the unavoidable restraints imposed upon it by the various portions of the machine, and an allowance must be made for these losses of force in transmission, before we can ascertain the *effective* work.

12. The force of steam is almost invariably applied in a *cylinder*, and the work it is made to do is, to drive a *piston* alternately from one end of the cylinder to the other. This motion is communicated by a *piston-rod* to the machinery outside the cylinder. These parts are

represented in Fig. 14, C being the cylinder, P the piston, and R the piston-rod. In some engines, fresh strong steam, admitted at one end, drives out from the other the steam weakened by its expansion in the cylinder, and is in its turn, driven out by a fresh antagonist admitted at the other end. These, in which strong steam works against weak, are called *high-pressure* engines, because the steam used has a great elastic force. The locomotives on railroads are all of this kind; and the vanquished steam may be seen driven off in successive puffs. They are also used in many factories, particularly where it is wished to economise space, as they fit into a small compass. In the other kind, called the *low-pressure*, or *condensing* engine, the steam, after it has done its work, is condensed, leaving nothing to oppose the newly-admitted steam. Here, then, steam acts against vacuum, and no vapour can be seen issuing from the engine, as it is all turned again to water. This kind is generally used for stationary works, is safer, from not requiring steam of very great elastic force, and is more economical in fuel; it is also used in nearly all sea-going vessels.—Edward Purcell.

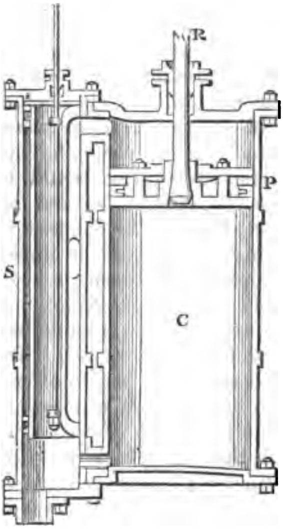


Fig. 14.

Manufactures.

LESSON I.

PAPER AND PAPER-MAKING.

BY GEORGE DODD.

> "The storied pyramid, the laurel'd bust,
> The trophied arch had crumbled into dust;
> The sacred symbol, and the epic song
> (Unknown the character, forgot the tongue),
> With each unconquer'd chief, or sainted maid,
> Sank undistinguish'd in oblivion's shade.
> Sad o'er the scatter'd ruins Genius sighed,
> And infant Arts but learned to lisp and died,
> Till to astonished realms *Papyra* taught
> To paint in mystic colours sound and thought;
> With Wisdom's voice to point the page sublime,
> And mark in adamant the steps of Time.
>
> * * * *
>
> Then pealed at intervals with mingled swell,
> The echoing harp, shrill clarion, horn, and shell,
> While bards, ecstatic, bending o'er the lyre,
> Struck deeper chords, and wing'd the song with fire.
> Then marked astronomers with keener eyes,
> The moon's refulgent journey through the skies;
> Watched the swift comets urge their blazing cars,
> And weighed the sun with his revolving stars.
> High raised the chemists their hermetic wands,
> (And changing forms obeyed their waving hands);
> Her treasur'd gold from earth's deep chambers tore,
> Or fused and harden'd her chalybeate ore.
> All, with bent knee, from fair Papyra claim,
> Wove by her hands, the wreath of deathless fame,
> Exulting Genius crown'd his darling child,
> The young Arts clasp'd her knees, and Virtue smil'd."

1. ASSUREDLY there have been few inventions attended with more important results than those relating to *Printing*. A manuscript may be regarded as a book; and, in this sense, books have existed from very remote periods of history; but it is the *multiplication* of books, the production of many copies of the same work, that constitutes the great benefit which we owe to the art of printing. There may be ten thousand persons reading the thoughts of one man at the same time; for ten thousand copies of a book may now be

procured as easily as ten copies of an ancient manuscript—thanks to the printing-press. The manufacture of a book, in an intellectual sense, is the silent and solitary work of the author; but the mechanical manufacture, in respect to the *Paper*, the *Printing*, and the *Binding*, is appreciable by all.

2. Most of the substances used as materials or as substitutes for paper are of vegetable origin. The *papyrus* of the Egyptians was made from a kind of reed growing on the banks of the Nile; and the paper of the early Chinese was made from the bark and other parts of plants. It is true that plates of lead and brass, bricks, stones, waxed boards, plates of ivory and of metal, and fish-skins, were used by various nations in early times, as writing-tablets; but from the time when the Chinese invented a mode of making paper from vegetable fibres beaten or cut into a sort of pulp, this kind of material has gradually superseded almost all others.

3. The ragged fragments of woven linen and cotton are the chief source whence the materials for paper are now obtained. As there is sometimes a scarcity of these fragments, attempts have frequently been made to employ other and more abundant substances. Straw can be made into a strong wrapping and packing paper, and at the present time straw-paper is manufactured sufficiently fine for writing-paper, although not equal to that ordinarily made of linen rags. During the last century numerous experiments were made on the relative fitness of different substances for paper. Jacob Christian Schäffer, a native of Ratisbon, produced six small volumes, the leaves of which consisted of no less than seventy different kinds of paper. The various specimens were made of inner bark, of leaves, of rind, of moss, of straw, of reeds, and of stalky fibres; some were grey, some brown, and others presented various shades between green and blue; the appearance was dull, shiny, granular, or fibrous, according to the texture of the substance employed. Another small volume was published in 1786, containing a portion of the works of the Marquis

de Villette, printed on paper made from the inner bark of the linden or lime-tree; and at the end of the volume are inserted several leaves of paper made from other substances, comprising nettle-fibre, hop-fibre, moss, reeds, weeds, couch-grass, hazel-wood, prick-wood, marsh-mallow, inner-bark of oak, inner-bark of poplar, and osier. The whole of the specimens are coarse and badly-coloured. Many attempts of a like nature have since been made; and there has lately been announced a mode of making paper from deal-shavings.

4. Notwithstanding all these experimental attempts, rags still constitute almost the only available material for paper; and the maintenance of a supply thus becomes an object of much importance. The Chinese, probably about the commencement of the Christian era, used rags of hemp, flax, cotton, and silk; and the Moors, who are supposed to have derived the art in some way from the Chinese, selected cotton as their chief material, and established cotton-paper manufactories in Spain. But it was soon obvious that hemp and flax make stronger paper than cotton; and about five centuries ago these materials began to supersede cotton. Linen rags, consisting of flax, became hence the paper-making material in all the countries of Europe. A portion of a man's worn-out shirt may form the material of the sheet of paper whereon he writes a letter; and that sheet of paper may afterwards be embodied in a papier-maché tea-tray—so curious are the transformations in manufactures. Some governments prohibit the exportation of linen rags, in order that the materials for paper may not fail in quantity. England requires much more than her own supply of such rags, and imports largely from such foreign countries as are permitted to furnish the supply. These countries are chiefly Italy and Germany, whence the linen-rags are brought in bags, weighing about four-hundred-weight each. Not less than from eight thousand to ten thousand tons of paper-making materials are required annually by our manufacturers, in addition to

those obtained at home. It will be easily understood that the materials vary greatly in quality, when we remember how much the papers differ in substance and appearance. There is, besides ordinary *letter-paper* and *note-paper*, a large variety, comprising *plate-paper* and *India-paper*, for copper-plate printers; *lithographic-paper; photographic-paper; pottery-paper*, for printing blue ware; *tissue-paper; printing-papers* of many degrees of fineness; *cartridge, blue, brown, whity-brown*, and other kinds of *wrapping* or *packing-paper; blotting-paper; filtering-paper; copying-paper; card-paper; sugar-paper; sheathing paper* for shipwrights; *tip-paper* for hatters; *coloured and marbled* paper for various ornamental purposes; and several other kinds used in small quantity.

5. A clear understanding of the mode of making a sheet of printing-paper, such as that used in the present book, will be sufficient to render intelligible the operations of paper-making generally. The first process, of course, is to prepare the rags for their destined work. When the bags containing them are opened, the rags are very minutely sorted. Linen is separated from other substances; fine linen from coarse; much-worn linen from that which is little-worn; coloured rags from white; hems and seams from the unsewn portions. The rag-merchants separate the rags into five or six kinds or qualities; but the paper-maker has to carry this classification much farther. In the best mills, the rags are shaken about in a revolving cylinder, to remove some of the dust before the sorting begins. Women and children, standing at tables covered with wire-cloth, cut the rags into bits, according to the quality, and sort them; during this process much dust falls ough the wire-cloth into a receptacle beneath.

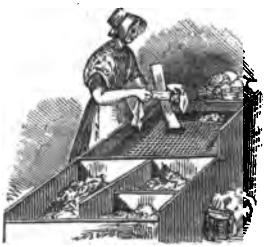


Fig. 1.

6. When the rags are dusted and sorted, they are washed quite clean with hot water and soda, in large vessels suitable for the purpose; and they are then ready to be ground or pounded into a pulp. There is a hollow vessel, in which rotates a cylinder furnished on its surface with numerous sharp knives; the rags, having been partially opened and disentangled by a stream of water, are lowered into this vessel; they are caught between the knives and teeth set in the bottom of the vessel, and are so cut and torn as to be brought to a state of great fineness. Not only are the warp and weft threads of the woven fabric separated, but every single thread is cut into minute fragments, and the whole forms a mere pulp or creamy paste. Some of the machines now employed have so many teeth in the interior, and knives on the cylinder, and revolve with such great rapidity, that they make from ten to twenty thousand distinct cuts every minute, each cut effecting something towards the separation of the rags into pulp. The rags are bleached with chloride of lime, or some other chemical agent, sometimes before they pass from the washing-engine to the *beating-engine*, but occasionally at another stage in the operations.

7. The transformation of this pulp into thin and beautifully-even sheets of paper is one of the most surprising operations in the whole range of manufactures. Whether conducted by the hand-method, or the machine-method, the results obtained are almost inexplicable to persons who are merely looking on:—so difficult does it appear to spread out the pulp in a layer sufficiently equable. The machine-method is but an extension of the older and simpler method of making the paper by hand; and therefore it will be desirable to describe this simple operation.

8. First, three men work together—the *dipper*, the *coucher*, and the *lifter;* and their chief working tools are the *mould* and the *deckle* or *deckel.* The mould is a square frame a little larger than the sheet of

paper about to be made, and covered at the top with a tightly-stretched wire-cloth; the parallel marks in foolscap paper, and the 'water-marks' in all paper, are produced by the wires of this cloth; but when the wires are woven into very fine gauze, the mould will produce *wove* paper, smooth and without marks. The deckle is a thin square wooden frame, as large on the outside as the mould, and on the inside as the sheet of paper; when laid upon the mould, the two together form a kind of shallow sieve. Such is the simple apparatus; and the mode of using it is as follows:—The pulp is collected in the *stuff-chest*, where it is mixed to the proper degree, white or slightly tinted according to the sort of paper intended to be produced. From the stuff-chest it is drawn off into tubs or vats, where it is kept warm by fires conveniently placed, or by steam-pipes. One of the workmen, the *dipper*, having thoroughly-well mixed the pulp, takes the mould in both hands, with the deckle closely pressed down upon it; he dips one edge into the pulp, draws up a little of the latter, pours off all that he deems likely to be superfluous, and by a series of peculiar movements causes all the rest to flow equally over the whole surface of the wire-cloth. When some of the moisture has drained through the meshes of the wire-cloth, the mould is laid down; the deckle is removed, and is placed upon a second mould; and the dipper proceeds to make a second sheet in a similar way. Meanwhile a second workman, the *coucher*, commences his duties: he holds the mould in an inclined position, to allow more of the moisture to drain off; he spreads

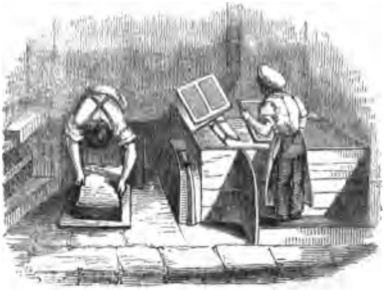


Fig. 2.

out a piece of felt and dexterously turns over the thin film of pulp from the mould upon the felt; he then hands the mould over to the dipper, who again uses it as before. The coucher places another piece of felt on the sheet of pulp—then another sheet—then a third felt; and the men thus proceed until they have accumulated a pile of sheets, called a *post*, comprising six or eight quires. The pile or post is placed in a screw-press, where a heavy pressure expels the remaining moisture, and smooths and consolidates the sheets. The *lifter* then sets to work; it is his duty to unscrew the pile, separate the sheets and felts one from another, collect the sheets from several piles into a larger pile, and subject this to the action of a second press, which still further dries, smooths, and consolidates the sheets.

9. The sheets of paper are thus made; but much has yet to be done for their completion. They are separated into small portions of six or eight each, and these parcels are hung upon horse-hair lines in drying rooms, where they are left until quite dry. They are then dusted, sized, pressed, dried, examined, and once more pressed; all the imperfect sheets are removed; and the good sheets are arranged and pressed, re-arranged and re-pressed, until every sheet has given smoothness to, and received smoothness from, its next neighbour. The sheets are then collected into quires of 24 each, and into reams of 20 quires.

10. This simple but ingenious mode of making paper is necessarily slow, although three men can make twenty 'posts' in a day; and it is natural that, in a mechanical age, some method should be sought of effecting it by machinery. In 1799, M. Didot introduced a paper-making machine in France, invented by one of his workmen, M. Robert. He obtained patents in England in 1801 and 1803, which were assigned to Messrs. Fourdrinier, who, by the aid of Mr. Bryan Donkin the engineer, surmounted many practical difficulties, and introduced effectually the making of continuous paper by machinery. From that time

scarcely a year has elapsed without improvements relating to some parts or other of these machines; until at length the paper-making machine has become quite a triumph of ingenuity.

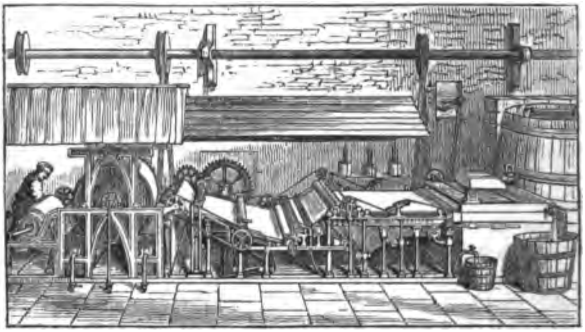


Fig. 3.

11. The pulp is, in the first place, collected in a vat or tub at one end of the machine, and is kept constantly stirred or agitated; a jet of steam, too, keeps it heated to a proper temperature. The pulp finds its way from the vat to a strainer, which frees it from lumps and knots; it then flows over a kind of leathern apron, and falls upon an extended surface of wire-cloth. This wire-cloth is in some machines nearly 30 feet in length, by 4 to 8 feet in width, according to the kind of paper to be made; and it is so fine as to have meshes less than I-60th of an inch across; the cloth has moveable raised sides or deckle-edges, and it has a rapid lateral motion imparted to it. When, then, the pulp flows upon the wire-cloth, it spreads itself out, and the superfluous liquid portion is shaken through the meshes into a vessel beneath. The wire-cloth travels slowly onward horizontally, with its delicate burden of pulp; and in its course it passes over a vacuum-box, whereby much of the water becomes sucked out of the thin layer of pulp. Onward the wire-cloth travels, passing next

between two pairs of rollers, which slightly press the pulp. The film then transfers itself to an endless web of felt, which passes between two iron rollers. The film, now consolidated into a tolerably firm sheet, passes from felt to roller and from roller to felt, and then over and under several steam-heated cylinders, and at length winds itself upon a reel or drum in a perfectly dry state. All this is extremely interesting to witness; for the paper forms an endless or at least continuous film, of which one part is being wound, dry and smooth, upon a drum, while another part is mere pulp just received from the vat: we can see the paper growing, as it were, under our eyes. The whole course of travel occupies less than two minutes; and it is really in this short space of time that the creamy pulp becomes converted into an endless sheet of dry paper.

12. An endless sheet it might be, so far as the principle of the machine is concerned; but practically there is, of course, a limit to the length. When the reel, or drum, becomes filled with as great a length of paper as it can conveniently retain, the paper is severed, and another reel adjusted. The cutting of the long roll of paper into sheets is sometimes effected in the paper-machine itself, and sometimes by a distinct apparatus. One full-sized machine will produce a mile of paper in three hours, and therefore the cutting into sheets becomes an important matter.

13. Some papers have a bluish tinge: this is given to them by a slight admixture of smalt or of artificial ultramarine with the pulp. Some have a detective red or blue line running through every sheet, as in post-office envelopes and exchequer-bills; this is effected by introducing a silken thread in the film of pulp. Some kinds of paper are hot-pressed or glazed; the hot-pressing is produced by placing in a screw-press a pile of heated iron plates and of sheets of pasteboard, with the sheets of paper interspersed among them; while the glazing results from passing the sheets of paper, interleaved with bright plates of copper, between pressure-rollers; and when

these processes are both combined and repeated several times, the paper may be brought up to a high degree of beauty and finish. The names given to paper, to indicate sizes, are very numerous, and not less fanciful than numerous:—*antiquarian*, *double elephant*, *atlas*, *columbier*, *elephant*, *imperial*, *super-royal*, *news*, *royal*, *medium*, *demy*, *post*, *copy*, *crown*, *foolscap*, *pott*. Some of the paper now made possesses extraordinary strength, relatively to its thickness. Many of the readers of this work may remember that, during five or six months at the Great Exhibition, there was a sheet of bank-note paper held up vertically, with iron-weights suspended from its lower edge to the amount of 230 lbs.!—GEORGE DODD.

Natural Philosophy.

BY JOHN TYNDAL.

LESSON I.

1. WHEN a boy hears a peal of thunder; when he sees a flash of lightning; when he watches the clouds forming, and views them afterwards discharging, their contents as rain, hail, or snow; when he observes upon a winter morning the grass of the fields covered with a hoar frost, and finds the same grass in summer adorned with pearls of dew; when he hears the melodious song of the lark, and observes the little bird securely floating in an atmosphere which is unable to support a straw; when he reflects upon the fire which warms him, and upon the flame which gives him light—there is nothing more natural than that he should desire to be instructed regarding the nature and causes of all these things. He sees a man fire a gun at a distance, notes the spark first and hears the sound afterwards, and the question arises, how is it that this difference is not perceived when he stands close to the gun, for then the sound and the spark occur simultaneously. How is it

that in a thunder-storm the flash is seen before the peal is heard? Can it be that when we stand at a distance the light leaves the sound behind it, as the quicker of two boys outruns the slower and arrives first at the winning-post? Do light and sound really require time to travel from one place to another, and if so, can we not contrive means to measure the speed at which they travel? Now the objects which we have supposed to attract the boy's attention are a few of a multitude which are continually presented to us in our present state of existence, and to these objects we give the name of *Natural Phenomena.* In addition to the desire to know the character and causes of these phenomena, human beings are endowed with the power of discovering and comprehending these causes. We already know a great deal concerning all the subjects to which we have alluded, and to knowledge of this kind, when properly extended and arranged, we give the name of *Physics* or *Natural Philosophy.*

2. An acquaintance with natural philosophy is so pleasant to beings gifted with the desire for knowledge, that the subject would be pursued on this account alone, even if there existed no other motive for its cultivation. But it so happens that, by observing and reasoning upon the phenomena of nature, we become better acquainted with the forces which produce these phenomena; so that finally we are enabled to enlist these forces in our service and to make them perform our necessary work. Anybody who looks into one of our immense factories, with its multitude of wheels and spindles, where a vessel of boiling water keeps the vast machinery in incessant motion; or upon a locomotive, drawing after it with the speed of a storm a train of fifty carriages full of passengers and merchandise, must feel the immense advantage which the world has derived from the study of the properties of steam, and of the means by which its force may be usefully applied. The electric telegraph is another example of the same kind; and although the great man who discovered that mysterious

power which acts through the telegraphic wire never gained a shilling by it—never indeed entertained the idea of making it the means of sending messages across continents, or even along the bottom of the sea, in the twinkling of an eye—though his investigations were prompted by far other considerations than those which people usually, but often thoughtlessly, call *practical*—his labours are not on this account the less a blessing to mankind.

3. GENERAL PROPERTIES OF MATTER.—The source of all the phenomena embraced by natural philosophy is *matter:* this is the foundation stone of our building, and we shall commence with it. Plain as the subject may appear, philosophers have disputed much regarding matter; and the probability is that every reflecting youth, after he has arrived at the years of manhood, will discover that the subject is not quite so simple as at first sight might be imagined. If a boy be asked, 'What is matter?' he will be able to show at once, by illustration, what he believes it to be. He takes up a brick or a stone and replies, 'This is matter.' He points to a tree or an animal and says, 'That is matter.' He stretches out his arm and exclaims, 'This is matter.' But if he be asked to define in words what matter is, he will not find the task an easy one. He finds, for example, that the stone which he held up as an illustration is hard, and may be tempted to say that matter is that which is hard to the touch; but a moment's reflection shows him the insufficiency of this definition; it shows him that *hardness*, as he understands the term, is not a *general property* of matter, for there are many kinds of matter, such as oil, butter, wool, &c., which are not hard. Hardness is what is called a *specific* property of matter; but it is those properties which characterize matter in general which now interest us, and some of which we will proceed to describe.

4. The first, and perhaps sufficiently distinctive, property of matter, is the ability it possesses of excluding all other bodies from the space occupied by a portion of it.

This property has received the name of *impenetrability.* If you enter a dark room and stumble against a table, you are conscious of meeting something which resists your progress. You can feel round the table and thus make yourself acquainted with its *form;* but the wood of the table occupies a certain space into which your hand cannot enter. You may reply that if a nail be driven into the wood, the latter will be penetrated by the nail, and this is perfectly correct, in the common sense of the term penetration, but not in our sense of the term. When we reflect a little it becomes evident that the nail merely *displaces* the particles of the wood; it pushes them aside, and does not by any means occupy the same portion of space that they occupy. In like manner, if you dip your hand into water, the liquid appears to be penetrated by your hand, but it is not a case of penetration in our sense of the term. If the vessel, before the immersion of the hand, be quite full of water, when your hand is itnroduced, a portion of liquid, exactly equal in bulk to the hand, will flow over, thus proving that the water is *displaced*, and not *penetrated.* If the liquid be contained in a cylinder into which a piston is so tightly fitted as to render displacement impossible, when the piston is pressed down upon the liquid, its descent will be resisted with a force which is scarcely to be surmounted. If you submit air, which appears to be so easily penetrable, to the same experiment, you will find that it also possesses a power of resistance. And, although the air may be squeezed into a smaller space, this is due to the fact that the particles of air are brought by the pressure more closely together, and is no proof that a single particle of air and a single particle of the piston occupy one and the same space at the same time; which latter, it must be remembered, is the real meaning of penetrability.

5. Another general property, which, in connexion with that of which we have just spoken, is usually deemed sufficient to characterize matter, is *extension.* But the idea of extension appears to be included in that of

impenetrability; for the latter term signifies the exclusion of all other bodies from the space occupied by any one body, and the mere occupying of space is extension.

6. A third general property of matter usually dwelt upon in works on natural philosophy, is its capability of being divided into parts. This property is called *divisibility.* A piece of chalk can be broken into two pieces; each of these two pieces can be also broken, and if we ask ourselves whether there be any end to the possibility of breaking, we find ourselves unable to imagine any such end. We are unable to conceive of a piece of matter so small that a still smaller one is impossible. The truth of this will be at once evident on reflection, and it has led philosophers to the conclusion that matter is *infinitely* divisible; that if our senses, or our instruments, were fine enough, we might go on dividing for ever, and never come to an end.

7. A few examples showing the minuteness of division of which matter is capable may be here introduced. We have referred to chalk. This substance has been shown by a German philosopher named Ehrenberg to be a collection of shells. Look at a piece of chalk; you cannot see those shells, for they are too small to be seen by the naked eye, yet they exist; and, not only so, but each one of them is built up of perfect little crystals of calcareous spar, myriads of which go to form every invisible shell. But in art, as well as nature, we have instances of the extreme divisibility of matter. It would take nearly 300,000 layers of common gold leaf, placed one above the other, to form a pile one inch in height. In certain gilding processes the layer of gold placed upon the gilt substance is so thin, that a portion of the layer whose weight does not exceed the 1,000,000,000th part of an ounce is distinctly visible to the naked eye. When a soap-bubble is distended by blowing, it becomes thinner and thinner, and finally bursts; but before it bursts a beautiful play of colours is observed upon its surface, and from these colours the great Sir Isaac Newton was

enabled to determine the thickness of the film. He found that just before bursting the bubble, at its thinnest point, was $\frac{1}{2,500,000}$ of an inch in thickness. Oil is also capable of great distension: if the smallest drop of oil be permitted to fall upon water in which a little caustic potash has been dissolved, it will seem to flash into colours which overspread the surface of the water; and these colours, like those of the soap-bubble, indicate that the thinness of the layer of oil is extreme. From the colours which they exhibit we also infer that the shining wings of dragon-flies and other insects are not thicker than gold-leaf.

8. The blood of animals owes its redness to little globules which float in a transparent liquid, called lymph; and it has been calculated that a drop of human blood, which may be suspended from the point of a fine needle, contains three millions of those red globules; while a similar drop of the blood of the musk-deer contains one hundred and twenty millions of them. Conceive a grain of sand of such a size as just to cover the dot placed over the letter *i* in these pages; there are animals so small that whole millions of them, grouped together, would not be equal in size to such a grain of sand. These are the results of microscopic research; but the microscope merely opens the door to imagination, and leaves us to conjecture forms and sizes which it cannot reveal. Turn your thoughts for an instant to the animals last mentioned—think of the apparatus by which the life of such animals is sustained: of their digestive organs—of their veins and arteries—of the little heart which impels the blood through these channels—of the globules floating in this blood—and then form, if you can, a distinct idea of the extent to which matter is actually divisible.

9. And yet, though the human mind is unable to conceive of a piece of matter so small as not to be capable of further division, it is perfectly possible that a real limit may exist to the divisibility of matter. It has been supposed that matter is composed of

particles, called atoms, smaller than any that we have been considering, and so hard that it is impossible to divide them further; and this opinion, or something closely resembling it, is general at the present day. A lump of copper, for example, is a collection of the atoms of copper, clinging closely together: the same may be said of a lump of gold, silver, lead, or sulphur. To those substances, which are incapable of being reduced to others more simple, chemists have given the name of elements or simple bodies: there are more than sixty such elements, all the substances which we have just mentioned being examples of elementary bodies. The air we breathe is a mixture of two kinds of gas, called *oxygen* and *nitrogen*, each of these being a simple body. The word '*mixture*' is here used intentionally, but I must now ask you to figure to your minds an atom of oxygen and an atom of nitrogen in presence of each other: under certain circumstances these atoms may be caused to unite together, so as to form a single compound atom, or molecule, as it is sometimes called; and the gas which is produced by this union is so entirely different from the mixture of oxygen and nitrogen present in the atmosphere, that the person who inhales it soon becomes intoxicated and usually laughs immoderately; the gas receiving, on this account, the name of *laughing-gas*. This example will, I trust, fix upon your mind the difference between a mere *mixture* of two simple bodies and the compound produced by the *chemical union* of the same two bodies: in the former case the atoms of each substance are independent of those of the other; in the latter case the elements unite together, lose their individual characters, and produce an entirely new substance, this new substance being, not a simple body, but a compound one.

10. Most of the substances which we see around us are of this compound character. The water we drink is produced by the union of two other bodies, oxygen and hydrogen, although each of these bodies is a gas,

and neither of them has ever been observed in the liquid condition. The salt we use at table is produced by the chemical union of a gas called chlorine with a metal called sodium, neither of which substances bears the slightest resemblance to salt. Not only can one simple body combine with another, but compound bodies may also unite together to produce other bodies still more complex. There is, for example, a heavy gas which often collects at the bottoms of deep wells, and sometimes kills people who enter such wells incautiously: the gas is a compound of the element *carbon* with oxygen, and is called *carbonic acid*.

11. The lime used for building purposes is a compound of a metal called *calcium* with oxygen, the product being called *oxide of calcium*, or lime. Now the carbonic acid just referred to has the power of uniting with the lime and forming a body called *carbonate of lime*, totally distinct from either. Marble is carbonate of lime; so is chalk, and so is the beautiful transparent crystal called Iceland spar. A difference in the arrangement of their particles often makes substances chemically alike exhibit totally different appearances. Sulphur, for example, may be yellow, red, or black, according to the manner in which it is prepared; but it is still sulphur. What two bodies can be more different from each other externally than the sparkling and costly diamond and a lump of dingy charcoal? Yet they are precisely the same substance, and the diamond, hard and beautiful as it is, can be burnt like a piece of coal. We might proceed further in this way, but sufficient I think has been said to give you some idea of the views now entertained by philosophers regarding the nature and properties of matter.

12. But there is one other property so remarkable, and so common, that I am unwilling to pass on to the next chapter without alluding to it; and that is the wonderful power which atoms and molecules possess of arranging themselves together so as to form crystals. If we examine almost any rock, we shall find it to be,

in a great measure, composed of little crystals, which shine and sparkle in the sunlight when their clean surfaces are exposed. Here, however, the crystals are confusedly mingled together, but under certain circumstances they grow to a large size, and thus enable us to study their exact forms and properties. Crystals of quartz, or rock-crystal, as it is usually called, are often found weighing several pounds.

13. The crystal sketched in fig. 1, consists of a column, or prism, possessing six sides, and having its

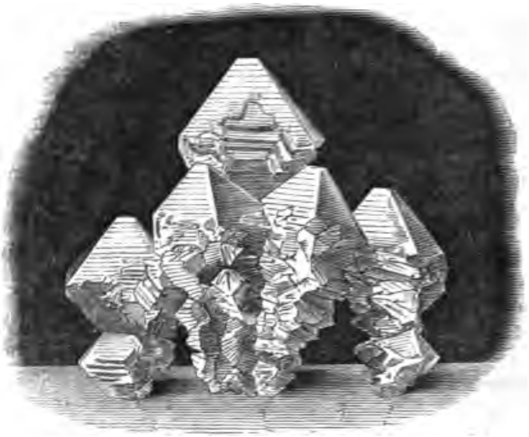


Fig. 1.

two ends capped by pyramids: the crystal, however, is rarely found with both ends perfect. In all rock-crystals, no matter where they may be found, this form can be recognised: other bodies crystallize in other forms, and sometimes the same substance possesses the power of crystallizing in two or three different forms. Sulphur is a striking example of this. Carbonate of lime crystallizes in two forms, the crystals of one form being called arragonite, and those of the other, calcareous spar. If a piece of rock-salt be struck with a hammer, it will split freely in three different directions, which are at right angles to each other, and however small the fragment may be it retains this peculiarity. The substance *cleaves* into cubes, and possesses this character wherever it may be found. Calcareous spar may be similarly cloven, not however into cubes, but into figures called rhomboids. All crystals, even the hardest, are more or less cleavable; and lapidaries taking advantage of this property, instead of grinding down diamonds and other precious stones, sometimes cleave them, the surfaces exposed by cleavage being perfectly smooth and shining. If you carefully examine with your penknife a piece of sugarcandy, which is crystallized sugar, of tartaric acid, or of citric acid, you will probably find that it cleaves with facility in one direction; indeed, I cannot recommend you a more useful exercise in connexion with this portion of our subject than the finding out of the principal cleavage of these crystals. I am sure, when you find the cleavage, you will be pleased with our discovery, and the labour spent in solving the problem will be well repaid by the superior knowledge of the structure of the crystal which you will assuredly acquire.

14. The term '*principal cleavage*' has been used, because sugar, and many other crystals, cleave less perfectly in some directions than in others. The *angles* of crystals are constant in size, but the case is different with the *surfaces*; for the circumstance of a crystal lying upon any object, say upon the bottom of a plate, during its formation, will tend to flaten the side in contact with the plate, and to make it larger than its fellows; thus figs. 2 and 3, represent different forms of crystal of the same substance as alum.

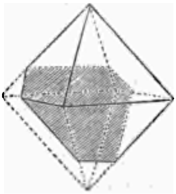


Fig 3.

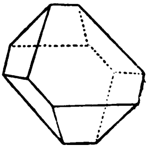


Fig. 2.

15. If you dissolve a quantity of glauber salts, or saltpetre, in water, and place the solution in a basin where it can evaporate slowly, you will soon find crystals forming round the sides of the vessel, which become larger and larger as the solution continues to evaporate. If permitted to rest against the bottom, the surfaces, as already remarked, will not be regular; but it is possible to raise a small crystal from the bottom, and to suspend it in the middle of the liquid, and by little artifices of this kind crystals may be *nursed* so as to grow to a large size and to preserve a perfect form. The crystals of feldspar, figs. 4 and 5, though apparently different, will on examination, be found to have exactly the same faces. Now how are those beautiful crystalline forms produced, whose architecture is so perfect, and whose characters are retained with such wonderful precision? Observe a bricklayer building a wall; he lays brick to brick, and the wall grows gradually larger: does it not appear as if, in the case of crystals, some invisible architect added molecule to molecule, and thus built up the entire mass? But we obtain truer notions of the process, though not less calculated to excite our astonishment, if we suppose the little molecules endowed with forces which compel them to arrange themselves in a particular manner. If we imagine the bricklayer absent, and the materials with which he works endowed with the power of arranging themselves so as to form walls, houses, steeples, and monuments, the wonder would not be greater than that which actually takes place in the building of a crystal.

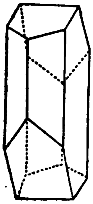


Fig. 4.

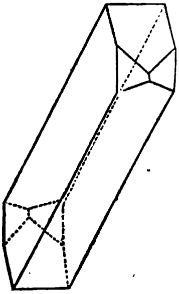


Fig. 5.

LESSON II.

ON FORCE AND MOTION.

1. **Definition of Force, &c.**—Towards the conclusion of the last chapter, the word *force* was made use of, and you have a right to require of me that I should not use a term, and leave you in doubt as to the meaning of it. We have already spoken of matter, and we cannot think of force without thinking of matter at the same time. *Force is that which puts matter in motion, or which stops or changes a motion once commenced.* Forces are of different intensities or magnitudes: a stone, for example, urged with all his strength by the arm of a man, will move with greater force than the same stone when cast from the hand of a child. But, however strong the man may be, we always find that the stone he throws soon sinks to the ground; and the reason of this is, that the stone is pulled down by a power possessed by the earth, and which we call *the force of gravity.* All matter possesses this force; and it is it which, acting across the interval of ninety-five millions of miles, holds the earth as surely in her orbit as if she were connected by a chain with the sun. The same force holds all the other planets in their orbits; and it is usual to distinguish it from the force which holds the particles of substances together, and enables a body to resist being broken or torn asunder, which latter is called *the force of cohesion.*

2. We might add to our definition of force, that it *prevents* motion, as the force of cohesion does this, for it resists the separation of a body's particles. Different bodies possess different powers of cohesion; the cohesion of chalk is far less than that of the flint embedded in it; and the cohesion of bone is greater than that of muscle. But not only do different bodies differ in this respect, but the same body may possess different powers of cohesion in different directions. Wood, for example, splits with greater ease in the

direction of the fibre than in any other direction; and the cleavages of crystals, spoken of in the last chapter, also indicate that in some directions the force of cohesion is less than in others. In the direction at right angles to the fibre of wood, and to the cleavage of a crystal, the particles are held together by a comparatively feeble force. It would be well to dwell upon this a little, and to obtain a clear notion of the fact, that to cleave with greater ease in the direction of the fibre, the particles must be held together by a feebler force perpendicular to the fibre.

3. INACTIVITY OR INERTIA.—There is a certain quality of matter which, though properly speaking, it is not a force, may be referred to here; and that is, the tendency of matter to remain at rest, if unmoved by any external agency, and of persisting to move after it has once been set in motion. It has been asserted, that rest is natural to matter; but this is an error: matter has no more preference to rest than to motion, and is altogether incapable of moving itself, or of stopping itself when once put in motion. This property is called *inactivity* or *inertia*, which latter term has been often erroneously applied to express a tendency in matter to resist being moved, there being in reality no such tendency. It may be urged that bodies do cease moving; that the ball thrown from the hand of a cricketer, after rolling for some distance along the grass, comes finally to rest. But this stoppage of motion is not due to any power possessed by the ball to stop itself, but is simply due to the impediments presented to its progress by the grass, and the inequalities of the ground over which it rolls. Urge the same ball, with the same force, along a flagged surface, and it will proceed much further: substitute for the flags a sheet of smooth ice, and it will proceed still further: take instead of the rough cricket-ball, a sphere of polished marble or ivory, and it will preserve its motion for a greater length of time. Thus it is seen, that in proportion as we remove impediments, the motion of the ball

is prolonged; and it is fair to conclude, that if all impediments were removed, the motion would continue for ever.

4. A bullet fired from a gun enters a certain distance into wood: into mud it will enter still further: into water further still; and furthest of all into air. But even in air a great resistance is presented to the bullet; and in none of the cases mentioned have we an example of really ceaseless motion. Such examples, however, exist: there is no grass, no water, no air in the track of the earth and planets as they twirl around the sun; and the consequence is, that these bodies have continued to roll through countless ages, with the velocity which they possess to-day. For it must be borne in mind, that there is no incessantly active force urging the planets forward, and compelling them to keep up their speed; the only constant force which acts upon them is the attraction of the sun; and this, if left unchecked, would soon draw sun and planets together. The single impulse, by which we may imagine these masses sent spinning through space, is the sufficient cause of that persistency with which their courses are run.

5. Illustrations of Inertia.—Many things of common occurrence are to be explained by reference to this quality of inactivity: we will here state a few of them.

When a railway train is moving, if it strike against any obstacle which arrests its motion, the passengers are thrown forward in the direction in which the train was proceeding. Such accidents often occur on a small scale, in attaching carriages at railway stations. The reason is, that the passengers share the motion of the train, and, as matter, they tend to persist in motion. When the train is suddenly checked, this tendency exhibits itself by the falling forward referred to.

In like manner, when a train, previously at rest, is suddenly set in motion, the tendency of the passengers to remain at rest evinces itself by their falling in a direction opposed to that in which the train moves.

Matter has no power of changing the direction of its motion: on turning a corner suddenly, a horseman must lean towards the corner, in order to prevent his being thrown forward in the direction of his previous motion.

6. A rider at Astley's, standing on a horse's back, has the same motion as that of the horse which bears him; and when he jumps over a garter, or through a ring, he does not jump forward, although he appears to do so. He jumps straight upward, and the motion which he has already acquired carries him over the garter or through the ring.

If a cannon-ball be taken to the top of the mast of a swiftly-sailing ship, and let fall downwards, it might be imagined, that on account of the movement of the vessel, the ball would reach the deck at some distance *behind* the bottom of the mast; but this is not the case. Before the ball was released it partook of the motion of the ship, and allowance being made for the resistance of the air, this motion is retained by the ball, and prevents it from being left behind by the mast.

7. Nay, if we suppose the ship sailing from west to east, the ball, strictly speaking, will fall a little *in advance* of the mast. This is rather a difficult point, but I do not despair of making it clear. The earth turns from west to east, upon its axis, once in 24 hours; and hence, every point upon the earth's surface, with the exception of the two poles, must describe a circle daily. If you fix your eye upon any point on a globe, and turn the globe, you will see instantly what is meant; the point goes round in a circle. The circumference of the earth at the equator is 24,000 miles; and, therefore, a stone or other object at the equator, describing, as it does, a circle of the magnitude just mentioned, must move with a velocity of 1000 miles an hour. A point in England, however, moves with much less speed, because the circles described become smaller and smaller as we approach the poles; and there is no difficulty in understanding that the

larger the circle described in the 24 hours, the greater must be the velocity of the point which describes it. But it is evident that the top of St. Paul's, or of Salisbury spire, or of the mast of a ship, or the summit of any other high object, describes, as the earth rotates, a larger circle than the bottom of the same object; and for this reason, a body placed at the top will move with a greater velocity than at the bottom. Hence, when a ship sails from west to east, a ball at the masthead will, on account of the earth's rotation, move more quickly in an easterly direction, than the bottom of the mast; and retaining this superiority of motion after it is released, it must fall in advance of the mast instead of behind it. It will, probably, require a little time to familiarize the mind with this reasoning; but the time thus employed will be well bestowed. I cannot, indeed, recommend too strongly to boys, when studying natural philosophy, the patience of pondering upon subjects which at first sight may appear difficult; it is really wonderful what patience can accomplish here; and there is no delight equal to that experienced by a boy when he finds his perseverance rewarded by the conquest of a difficulty.

8. Let us now return to the study of force.

If a ball of light wood be let fall from a table upon a foot underneath, very little injury, if any, will be done to the foot; but if the ball be of lead, or of any other heavy substance, it may bruise the foot and cause considerable pain. It is evident that, in this case, the increase of pain is due to the increase of force with which the heavy body strikes the foot, or that the force increases as the weight increases.

A bullet projected from a musket barrel will pass through a board an inch in thickness, whereas a similar bullet cast from the hand will make but a slight impression on the board. What is the cause of the difference of force here exhibited? Not a difference of weight, as in the case last supposed, but a difference of *velocity*. The bullet issuing from the musket travels at a much greater speed than that cast from the hand, and hence it is that its force is so much greater.

9. In estimating the force of a moving body, therefore, two things are to be taken into account; the ***mass*** moved and the ***velocity*** with which it moves.

The following table, in which the velocities of various objects are stated, may be useful for reference.

Moving Objects.	Miles per hour.	Feet per second.
Man walking	3	4½
Horse trotting	7	10½
Swiftest racehorse.	60	90
Railway train (English). . . .	32	48
,, (American) . . .	18	24
,, (Belgian) . . .	25	37½
,, (French). . . .	27	40½
,, (German) . . .	24	36
Swift English steamboats navigating the Channel	14	21
Swift steamers on the Hudson . .	18	27
Fast-sailing vessels	10	15
Current of slow rivers	3	4½
,, rapid rivers	7	10½
Moderate wind	7	10½
A storm	36	54
A hurricane	80	120
Air rushing into vacuum . . .	850	1275
Common musket-ball	850	1275
Rifle-ball	1000	1500
24-lb. cannon ball	1600	2400
Bullet discharged from air-gun, air being compressed to 100th of its volume .	466	700
Sound through air at temp. 32° Fahr. .	726	1089
,, ,, 60° Fahr. .	747	1120
Earth moving round the sun . . .	67,374	101,061
A point on the earth's surface at equator, in consequence of diurnal rotation .	1037	1555

10. The Romans and other ancient nations were accustomed to batter down the walls of the city which they attacked by means of heavy instruments called battering rams. It was by means of such instruments that

breaches were made in the walls of Jerusalem, by the soldiers of the Roman Emperor Vespasian. But a glance at the foregoing table will be sufficient to show us why these unwieldy instruments have, in modern warfare, been quite superseded by cannon-balls. The possession of gunpowder enables us to impart a velocity of 2,400 feet a second to a 24-lb. cannon-ball; and this enormous velocity is more than sufficient to counterbalance the superior weight of the ram, and to convert the bullet into a far more formidable implement of destruction.

11. COMPARISON OF FORCES.—We have thus far contented ourselves with showing that the greater the weight, or the greater the velocity, the greater will be the force; but we must now be a little more precise, and endeavour to compare two forces together, so as to obtain an exact notion of their relative magnitudes. It requires a certain amount of force to make a body, weighing 5 lbs., move at the rate of 20 feet a second, and it is perfectly evident that it would require a greater exertion of force to make a weight of 10 lbs. move with the same velocity. If we suppose the mass of 10 lbs. cut into two equal portions, the force in question will be able to cause either of these 5 lb. masses to move at the rate of 20 feet a second, and if the said force be exerted *twice*, it will cause *both* the masses to move at the same rate. Hence we may infer that to cause a body weighing 10 lbs. to move through 20 feet a second, twice the quantity of force must be expended that is necessary to cause a weight of 5 lbs. to move through the same space, or, to speak more generally, the force of the moving body is proportional to its weight.

12. It is also found that the forces of two bodies of the same weight, but moving with different velocities, are proportional to the velocities; so that if one body move twice as fast as the other, it will possess twice the moving force, and if it move ten times as fast as the other, it will possess ten times the moving force.

13. But when the bodies differ both in weight and velocity, in the comparison of their forces, we must take both into account. Imagine a weight of 5 lbs: moving with a velocity of 10 feet a second; if we double the velocity, we double the force,—that is to say, a weight of 5 lbs., moving at the rate of 20 feet a second, possesses twice the force of the same weight moving through 10 feet a second.

But a weight of 10 lbs. moving through 20 feet a second possesses twice the force of a weight of 5 lbs. moving at the same speed. Hence a weight of 10 lbs. moving through 20 feet a second possesses *four times* the force of a weight of 5 lbs. moving through 10 feet a second: this shows us that if we double the weight and double the velocity we increase the force four times. A similar reasoning would show us that, if we trebled the weight and trebled the velocity, the force would be increased *nine* times; also, that if we trebled the weight and doubled the velocity, the force would increase six times; or, in other words, *that the force increases as the product of the weight and velocity increases.*

14. Indeed the product of the mass into the velocity is always taken as the expression of the force: our weight of 5 lbs. for example, moving through 10 feet a second would have a force of

$$5 \times 10 = 50,$$

and our weight of 10 lbs. moving through 20 feet a second would have a force of

$$10 \times 20 = 200,$$

and we see that the numbers 50 and 200, which express the forces, are in the ratio of 1 to 4, which is the same result as that proved above. If, therefore, we denote the mass of a body by the letter M, and its velocity by V, the force will be

$$M \times V.$$

This product is usually called the ***momentum***, or ***moving force*** of the body.

For the sake of imprinting this simple principle upon the mind, we will give a few examples of its application.

Example 1.—A ball weighing 9 lbs. moves with a velocity of 25 feet a second; it is required to compare its momentum with that of a 5-lb. ball moving at a speed of 45 feet a second?

Here we have $9 \times 25 = 225$.
And $5 \times 45 = 225$.

The products are equal, and hence we conclude that the momenta or moving forces of the two bodies are equal also.

Example 2.—A battering ram, weighing 5,300 lbs., was propelled with a velocity of 7 feet a second, it is required to compare its momentum with that of a 30 lb. cannon-ball moving at the rate of 2,492 feet in a second? By proceeding in the manner indicated it will be found that the momentum of the ball is about twice that of the ram.

15. It is evident that if of the three quantities, weight, velocity, and momentum, any two be given, the third may be found.

(1.) If the weight and velocity be given, we multiply them together to obtain the momentum.

(2.) If the momentum and velocity be given, we divide the momentum by the velocity to find the weight.

(3.) If the momentum and weight be given, we divide the momentum by the weight and obtain the velocity.

Example 3.—The weight of a body is 52, its momentum is 468, required its velocity?

$468 \div 52 = 9$ Answer.

Example 4.—The velocity of a body is 15, its momentum is 180, required its weight?

$180 \div 15 = 12$ Answer.

16. In all these cases we have only to be careful, that when we compare the forces of two moving bodies we must have their weights expressed in the *same unit*, and also their velocities expressed in the same unit. The unit of weight may be an ounce, or a pound, or a ton; and the velocity may be either so many feet in a second

or miles in an hour; but if the foot be taken as the unit of space and the second as the unit of time, in one case, the same units must be taken in the other. In the next lesson we shall have occasion to apply some of the simple principles established in the present one.

LESSON III.

COLLISION OF BODIES.

1. **Definition of Elasticity and Hardness.**—Before we enter upon the subject of the present chapter it is essential to obtain perfectly clear notions of what is intended to be expressed by the words *elasticity* and *hardness*. If a strip of India-rubber be drawn out, and then liberated, it will return to nearly the shape which it possessed before being stretched: in this case a force appears to reside in the particles of the rubber, which is capable of restoring the shape of the piece, and to this force we give the name of elasticity.

In like manner if we take a rod of glass and bend it, when the *deflecting* or bending force is removed the glass returns almost completely to its former position. If the same rod be softened by heat, and drawn out to a thickness not greater than that of a human hair, when cool it may be twisted; but when the force of twisting, or *torsion*, as it is called, is removed, the glass thread untwists itself, and the force which enables the glass to do this we call elasticity. Glass, indeed, is a very elastic substance, and I choose it, as an example, to show that great elasticity and great *brittleness* may exist together, in one and the same body.

Ivory is also a very elastic substance. If we permit an ivory ball to fall from a certain height upon a flat unyielding surface, the ball after it meets the surface will become flattened as represented at fig. 1, the force which the ball has acquired during its descent being all expended in compressing it. But the ball will not remain compressed, the particles which for a time had been forcibly brought closer together along the diameter A B, now make an effort to push themselves asunder; the ball recoils against the surface, and this back-push causes it to return along the path through which it had descended. If the force with which the particles push themselves asunder be equal in all respects to the force which had pressed them together, the ball is said to be *perfectly elastic*, and it will ascend to the same point from which it fell; but if this be not the case the ball is said to be *imperfectly elastic.*

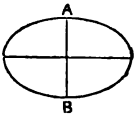


Fig. 1.

2. If after the shape of a body has been changed by any external force the new shape be retained, without any alteration, when the external force ceases to act, such a body is said to be *perfectly inelastic*: butter and soft clay approach to this condition, for if a lump of either of these substances be squeezed, or let fall upon the ground, it becomes flattened and *remains so;* but we are acquainted with no body in which elasticity is entirely absent, though many possess it in a very low degree; nor is there any body in which this elasticity is perfect.

3. Elasticity then is a force, within the body, which enables it to restore the shape which had been changed by a force without it. The property of *hardness* consists in the resistance to change of shape, and a body whose particles do not yield in the slightest degree to any external force applied to it, is said to be *perfectly hard.* Let us now inquire what will take place when a perfectly hard ball is permitted to fall upon a perfectly unyielding surface. Casting an eye upon fig. 1, we see that the rebounding of the ivory ball is solely due to the effort it makes to recover its shape; but, in the case of the perfectly hard ball, there is no change of shape, and consequently, no such effort. Hence it is evident that the hard ball will have its motion suddenly arrested by the surface, and will remain in contact with it, without rebounding.

We are now prepared to enter upon the subject intimated by the title of this chapter, and we will commence with the collision of such bodies as are assumed to be perfectly hard; for although this assumption is not strictly true, there being in reality no such thing as a perfectly hard body, as we have defined it; still the assumption will simplify our calculations very much, and where a practical object is sought, proper allowance for imperfect hardness can be made afterwards.

4. We will also suppose the balls we operate with to be *homogeneous*, that is to say, one part of the same ball must not be heavier than another; and we will further assume that when one ball approaches another, the direction of its motion is along the line which joins the centres of the balls, as shown in fig. 2: collision which takes place in this way, where the balls do not strike each other obliquely, is called *direct impact*.

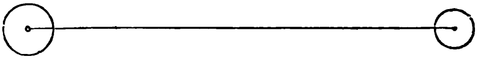


Fig. 2.

5. First, then, we will consider the case of two perfectly hard balls of the same weight, and possessing the same velocity, moving towards each other in *opposite directions*. It is evident, that, inasmuch as the forces with which the balls move are equal and opposite, the motion of both balls will be destroyed by collision, and thus will come perfectly to rest, as shown in fig. 3

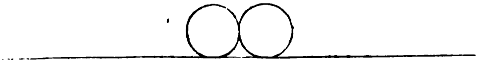


Fig. 3.

6. We will now vary the question, and suppose that the balls are not of the same weight, and do not move with the same velocity. Suppose, for example, that one of them weighs 9 ounces, and moves at the rate of 15 feet a second, while the other weighs 12 ounces, and moves in the opposite direction, at the rate of 10 feet a

second,—what will be the state of things after collision?

It is evident here that if the forces or momenta with which the balls move be not perfectly equal, the motion will not be completely destroyed when they strike against each other. The two balls will move together *as one mass* in the direction of that ball whose moving force is greatest. As explained in the last lesson, the moving force of each ball is found by multiplying its weight by its velocity; hence

9 × 15 = 135 momentum of smaller ball.
12 × 10 = 120 momentum of larger ball.

Now, as the momentum of the smaller ball is the greater of the two, it is evident that both balls will move together as a single mass in the direction of the smaller ball. These considerations will prepare us for a few examples, which will serve to illustrate this interesting subject.

Example 1.—A ball A, moving at the rate of 25 feet a second, is followed by another, B, moving at the rate of 35 feet a second, the weight of the former ball is 12 lbs., and of the latter 8 lbs.; required the *common velocity* of the two balls after direct impact.

The first step, as before, is to find the momenta of the two balls.

12 × 25 = 300 momentum of A.
8 × 35 = 280 momentum of B.

Now I have reserved a statement to be made at this particular place, where it is essential to our progress, hoping thereby to imprint it more firmly upon the memory;—it is this—in the case before us *there is no force lost.* When the balls strike together, the quick ball imparts a portion of its motion to the slow one; but the *force* of the two balls after impact, and when they move together as a single mass, is precisely equal to the sum of the forces which they possessed before impact: let us add these two forces together;

300 + 280 = 580

This, then, is the momentum of a mass which is made up of the two balls,—or, in other words, which weighs 12 + 8 = 20lbs., and our question resolves itself into this:—Given the weight 20, and the momentum 580, to find the velocity. According to the process explained in the last chapter, we obtain the velocity by dividing the momentum by the weight; hence,

$$580 \div 20 = 29,$$

the common velocity after impact is, therefore, 29 feet a second.

7. If it be required to know the velocity lost by B and gained by A, we should find the former by subtracting 29, the velocity of B after impact, from 35, the velocity before impact, the velocity lost being 6 feet a second. By deducting 25, A's velocity before impact from 29, its velocity after impact, we obtain for A's gain 4 feet a second.

8. We can here subject our calculation to proof; for if what we have stated be correct, the *force* gained by A ought to be exactly equal to that lost by B; now the force gained by A is found by multiplying A's weight by the velocity which it has gained, or,

$$12 \times 4 = 48 \text{ A's gain of force.}$$

By a similar process, the loss of B is found to be

$$8 \times 6 = 48,$$

which shows that the force lost by one ball is precisely equal to the force gained by the other.

I trust you will study this example until it is perfectly plain to you; for if you succeed in obtaining a clear notion of every example as we proceed, each subsequent one will be a source of new interest and pleasure; while there is nothing but dissatisfaction and unhappiness experienced when a boy passes impatiently a new portion of his task, without having endeavoured to master the previous ones.

Example 2.—Suppose the same two balls as those introduced in the last question to move in opposite directions, instead of in the same direction, required the common velocity of the two balls after collision.

Now it is evident that if the balls moved with precisely equal forces, they would completely neutralize each other's motion by collision, and come to a perfect rest. Suppose the force on each side to be 300, we should, in the case of the balls moving in *the same direction*, find the combined force, after collision, to be $300 + 300 = 600$; but if they moved in *opposite* directions, we should find the force after collision to be $300 - 300 = 0$; the force producing visible motion would completely disappear, and rest would be the consequence. But, in the present instance, the forces do not completely neutralize each other, but a balance of

$$300 - 280 = 20$$

remains in favour of the ball A. The two balls, after impact, will therefore move with a force of 20 in A's direction; and the question now is;—given the weight, $12 + 8$ or 20, and the momentum 20, to find the velocity: dividing, as before, the momentum by the weight, the velocity is found to be 1 foot per second.

Example 3.—A ball, A, weighing 32 lbs., and moving with a velocity of 26 feet a second, follows another ball, B, the weight of which is unknown, but which moves at the rate of 12 feet a second; the common velocity after impact is found to be 20 feet a second; it is required from this to find the weight of the ball B.

We will here show how the principles of algebra may be applied to the solution of questions like the present:—

$$\text{Let } x = \text{the weight of B in lbs.};$$

then we have

$$32 \times 26 = 832 \text{ A's momentum,}$$
$$x \times 12 = 12x, \text{ B's momentum};$$

adding both momenta together, and dividing the sum by the weight of the two balls, we have

$$\frac{832 + 12x}{32 + x} = 20 \text{ the common velocity.}$$

Clearing of fractions, we have

$$832 + 12x = 640 + 20x$$
$$8x = 832 - 640 = 192;$$

or

$$x = 24 \text{ the weight sought.}$$

But for the sake of those unacquainted with algebra, we will solve the question differently. It may, however, be remarked, that a knowledge of algebra increases our power immensely in dealing with mechanical questions; and, in difficult cases, it is altogether indispensable.

The question before us enables us at once to find the velocity which A loses and which B gains by the collision; the former is evidently 6 feet a second, and the latter 8. We can also, by multiplying A's weight by its loss of velocity, find the *momentum* lost by A;—it is

$$32 \times 6 = 192.$$

Now this must be equal to the *momentum gained* by B, and the question therefore is;—given the gain of B in velocity 8, and in momentum 192; required the weight of B; we obtain it, as before, by dividing the momentum by the velocity,—

$$192 \div 8 = 24 \text{ the weight sought.}$$

9. A great number of interesting and pleasant questions might be proposed in connexion with this subject; and if the pupil understand the foregoing thoroughly, he will have no difficulty in imagining and exercising himself with others.

10. Distinction between Elastic and Inelastic Collision.—In the collision of perfectly hard bodies a certain amount of force is expended in communicating *momentum* from one body to another; and during this act the particles of the bodies are supposed not to yield in the slightest degree to the force of compression. But in the case now to be considered, the bodies are compressed during the communication of momentum, but they do not remain compressed; they instantly expand again with precisely the same force as that with which they were squeezed together, and the consequence is that in the collision of perfectly elastic bodies the gain or loss of velocity is exactly *twice* what it is when the bodies are perfectly hard.

11. When two equal and perfectly hard balls, moving with the same velocity, but in opposite directions, strike

together, they come to rest after collision without change of shape, as in fig. 4.

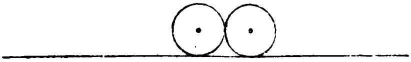


Fig. 4.

But if the balls be perfectly elastic they do not act in this way; both are flattened during the act of compression, as in fig. 5.

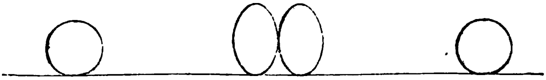


Fig. 5.

But when the flattening has attained its utmost limit, a mutual *push* is exerted by the two balls, which causes them to fly asunder with the same velocity as that with which they approached each other before impact. If, for example, each ball possessed a velocity of 9 feet a second before impact, this velocity is not only destroyed in each case, but it is converted into one in the opposite direction; and in this case it is usual to say that the loss of velocity is doubled. I know that this will appear a new notion of loss to many boys, inasmuch as the *absolute velocities* after impact are the same as before. The case may be illustrated by a parliamentary candidate who reckons on the support of a certain voter: if the voter dies, the candidate may be said to lose a vote; but if the voter change his opinion, as our ball has changed its direction, and votes for the opposition candidate, then the loss may be said to be doubled.

12. In the case of elastic collision, we cannot speak of the *common velocity* after impact, but the gain or loss of each ball must be determined separately.

Example 1. Two perfectly elastic balls, A and B, each weighing 8 ounces, move in the same direction; B moves with a velocity of 10 feet a second, and is followed by A at a speed of 15 feet a second: required the velocity of the two balls after direct impact.

Supposing A and B to be perfectly hard, the loss of A and the gain of B is found, in the manner already described, to be each 2½ feet per second; but in the case of elastic collision, the loss and gain are doubled, hence A's loss will be 5 feet, and B's gain an equal quantity. Deducting, therefore, 5 from A's velocity, and adding 5 to B's, we find the velocities after impact to be 10 and 15.

13. This result is worth bearing in mind, for it shows us that A's velocity after impact is the same as B's before impact, and that B's velocity after impact is the same as A's before impact. This holds good in all cases where the elastic bodies are equal, and move before impact in the same direction. *Two such bodies exchange velocities by collision.*

Example 2. A ball, A, of 9 lbs., moving with a velocity of 62 feet a second, strikes or impinges upon a ball, B, at rest, and possessing the same weight as A: required the gain and loss of velocity by collision.

Here we have the momentum of A before impact,

$$62 \times 9 = 558;$$

and, inasmuch as B has no moving force before impact, this must be the *momentum* of the two balls after impact. Hence, supposing the balls to be perfectly hard, we should find the velocity after impact to be—

$$\frac{558}{18} = 31.$$

If we deduct this from A's velocity before impact, and add it to B's, we should find the loss of the former 31, and the gain of the latter the same quantity. But as the balls are perfectly elastic, this gain and loss must be doubled; that is, A's loss is 62, and B's gain is 62. But if A's loss be 62, it has no velocity remaining, for its velocity before impact was only 62; and thus we arrive at the remarkable result, that if *an elastic body in motion strike another equal elastic body at rest, the moving body communicates all its motion to the other, and comes itself to rest.*

14. This result enables us to explain an experiment

often made with a row of ivory balls, all of the same size, as in fig. 6.

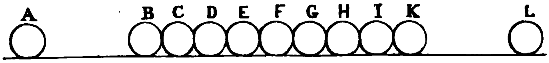


Fig. 6.

If the ball A be caused to strike the end ball B, it communicates its motion to B, and comes to rest itself; B communicates its motion to C, and comes to rest; C communicates its motion to D; D to E, and so on to K; K communicates its motion to L, which starts forward. If the balls were perfectly elastic, the velocity of L would be precisely equal to that of A at the commencement.

Example 2. A, weighing 30 lbs, and moving at 26 feet a second, impinges on B, weighing 28 lbs., and at rest: required the loss and gain of velocity by collision.

Treating them as perfectly hard balls, we should find the common velocity after impact to be $13\frac{13}{29}$; this would express B's gain, and deducted from 26 it would give $12\frac{16}{29}$ as A's loss; doubling these numbers we find the loss and gain when A and B are perfectly elastic.

Loss $25\frac{3}{29}$
Gain $26\frac{26}{29}$.

By comparing A's loss with A's original velocity, we see that the latter is not quite destroyed; in the question we have supposed A greater than B; and *where the impinging body is greater than the body at rest, the motion of the former, after impact, is always in the same direction as its motion before impact.*

Example 3. A, weighing 8 lbs., and moving at 12 feet a second, impinges on B, weighing 9 lbs., and at rest: required the loss and gain by collision.

Supposing the balls to be hard, the common velocity after impact is $5\frac{11}{17}$; hence A's loss and B's gain would each be equal to $6\frac{6}{17}$; doubling this we have the gain and loss for elastic balls equal to $12\frac{12}{17}$. If we compare A's loss thus found with its velocity before impact we see that the former actually exceeds the latter. The velocity before impact is 12, the loss is $12\frac{4}{7}$; this indicates that not only is A's velocity, in its first direction, all destroyed, but that it is partly converted into a motion in the *opposite* direction. This result is also general. If, in elastic collision, the impinging body be *less* than the body at rest, the former is *reflected back* by the collision.

15. To sum up:—

(1.) When both bodies are *equal*, the impinging body yields up all its velocity and comes to rest itself.

(2.) When the impinging body is *greatest*, its motion after impact is in the same direction as before.

(3.) When the impinging body is *least*, it is reflected back, along its to former path, by the act of collision.

LESSON IV.

ON TERRESTRIAL GRAVITY.

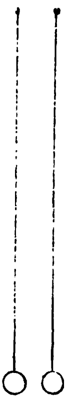


Fig. 1.

1. **Gravity**, as before explained, is that force by which matter attracts matter. If with two long strings two ivory balls were suspended from two pins, as in fig. 1, we should find, if our means of measurement were fine enough, that the two balls had approached each other, through the exercise of the mutual attraction subsisting between them. The attraction of such a suspended ball by a mountain has, indeed, been accurately measured. Very exact experiments have also been made to determine the attraction of a small ball by a very large and heavy one. A beam was suspended horizontally from its centre by a fine wire, and, at each end, a ball was fixed; near each ball a much larger one of lead was placed as in fig. 2; and by a proper mode of observation, the exact amount of the twisting endured by the wire, in consequence of the attraction, was ascertained. Such ex-

periments were made for the purpose of ascertaining the *density* of the earth, and it was thus found that its density is about five times that of water; that is to say, our world weighs as much, or contains as much

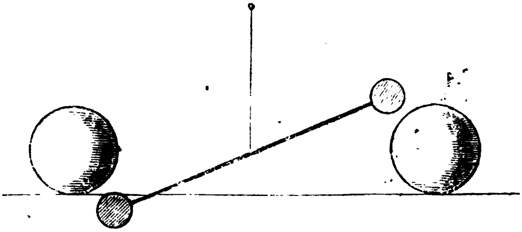


Fig. 2.

matter, as five worlds of equal size, and formed of common water. Such experiments incontestably prove that the attraction of gravity is not confined to the earth as a whole, but is exercised by all its parts. And be it remembered, that when we see a stone falling to the earth, that it is not the earth alone which is the attracting body; the stone also attracts the earth, but, on account of the immense mass of the latter, its motion *towards the stone* is so small as to be incapable of observation or measurement.

2. In considering the motion of any body, three things are to be taken into account: 1st, the *space*, over which the body moves; 2nd, the *time* of its motion; 3rd, the *velocity* with which it moves.

3. When the motion of the body is such that it passes over equal distances in equal times, the body is said to move with a *uniform* velocity. If, for example, we possessed a surface perfectly smooth and horizontal, and also a ball perfectly smooth, such a ball upon such a surface, when once set in motion by a single stroke, would, as already explained, continue to move without alteration of velocity. In this case, the force acting upon the ball, is what is called an *instantaneous* or *impulsive* force; it consists of a shock, the

motion impressed by the shock being retained by the ball without increase or diminution. The ball moves with a *uniform* velocity.

4. But the action of terrestrial gravity is not an action of this kind; it does not impart a shock and then cease: it is a *continuous* force, and not an instantaneous one. If a stone be let fall from the top of a high tower, gravity acts upon it during the whole course of its descent, and the consequence is that the stone moves quicker and quicker the longer it is in motion:—it moves with an *accelerated* velocity.

In like manner, if the stone be projected upwards, its ascent is opposed by gravity; in consequence of this it moves slower and slower, and finally ceases to ascend;—it moves with a *retarded* velocity.

5. In the case of uniform motion, if the velocity of a moving body, and the time of its motion be given, the *space* over which the body has moved will be found by multiplying the velocity by the time. Thus, supposing a body to move at the rate of ten feet a second, and that it had been in motion for seven seconds, the space over which it has passed will be

$$10 \times 7 = 70 \text{ feet.}$$

It is also plain, that if the space and the velocity be given, the *time* of the body's motion will be found by dividing the space by the velocity. Thus, supposing the space through which a body has moved to be seventy feet, and its velocity ten feet per second, then the time of its motion has been

$$70 \div 10 = 7 \text{ seconds.}$$

And if the space and the time be given, the *velocity* is found by dividing the space by the time. Thus, if a body has moved through the space of seventy feet, and been seven seconds in motion, its velocity has been

$$70 \div 7 = 10 \text{ feet per second.}$$

6. To sum up:—it is plain that if of the three quantities, *space*, *time*, and *velocity*, any two be given, then in the case of uniform motion, the third may easily be found.

7. **Investigation of the Laws of Falling Bodies.**—It is probably needless for me to tell the reader of this book what a *rectangle* is; that it is a four-sided figure, whose angles are all right angles, shaped, for example, like a school slate; and that the *area* is found by multiplying the length of the rectangle by its breadth.

8. Now, in the case of uniform motion, if we suppose the *velocity* to be represented by one side of a rectangle, and the *time* of motion by another, the *space* through which the body has passed, will be represented by the area of the rectangle.

Supposing, for example, in fig. 3, A B to represent the velocity 10, and B C the time of motion 5; then it is evident that the product of 10 and 5, which is the area of the rectangle, will also denote the space through which the body has passed.

Supposing, however, that after the body has been 5 seconds in motion, it receives a shock which increases its velocity from 10 feet a second to 15 feet a second; and that it moves uniformly with this newly-acquired velocity for the next 5 seconds, at the end of which it receives another shock, which increases its velocity from 15 to 20 feet a second, moving uniformly with this new velocity for the succeeding 5 seconds; supposing a motion of this kind to continue, suddenly increasing at the end of each 5 seconds, by the same fixed quantity, 5 feet, it is evident that the entire space passed over, in this case will not be represented by a single rectangle, but by a series of them. Thus, let A B, fig. 4, represent the velocity at the commencement, the rectangle A B C D will represent the space passed over in the first 5 seconds; the velocity then becomes greater, and must be represented by a longer line D E; the space passed over in the next 15 seconds will be represented by the rectangle D E F G: in like manner, the space passed over in the third period of

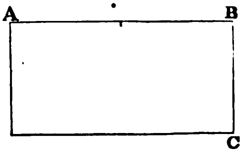


Fig. 3.

5 seconds will be represented by the rectangle F H I K; in the fourth period by the rectangle I L M N: the entire space passed over in the whole 20 seconds will therefore be represented by the figure A M N L H E B.

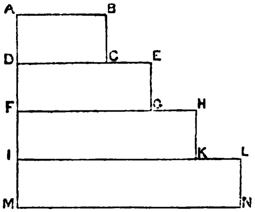


Fig. 4.

9. We will now suppose the velocity at the commencement to be much smaller than 10 feet a second, and will therefore represent it by a much shorter line; and also the accessions, or increments of velocity, to take place at shorter intervals—say at intervals of a second—these increments being proportionately smaller than in the former case. It is evident, that, proceeding as before, we should find the whole space passed over to be represented by the area of such a figure as A B M N, fig. 5.

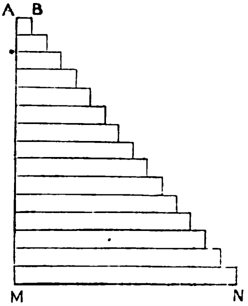


Fig. 5.

Now, it is plain that this figure approaches much nearer to the shape of a right-angled triangle than the last one; and a little reflection will render it evident that if we make the commencing velocity still smaller, and suppose the increments to follow each other more quickly, that we should obtain a still closer approximation to a triangle.

10. If, for example, the commencing velocity were almost nothing, the length of A B would be almost nothing also; and if the commencing velocity were really nothing, A B would lose all length, and dwindle to a mere point, A, fig. 6. And supposing the increments of velocity to take place in the thousandth or millionth part of a second, instead of a whole second,

it is plain that the stair-like appearance between B and N (fig. 5) would almost wholly disappear. And if the little shocks which produce the increments of velocity take place instantly one after the other, so as to melt into a continuous *pull*, the steps would vanish altogether, and the whole space passed over would be represented by the right-angled triangle A M N (fig. 6.)

11. Now, if we suppose a body to be let fall from a state of rest, and drawn to the earth by gravity, it is exactly in the condition which we have last supposed: the commencing velocity is nothing, and the force acting upon it is a continuous and constant pull; hence the whole space passed over by a falling body is accurately represented by the area of a right-angled triangle. The establishment of this principle places it in our power to solve a great number of interesting questions relating to terrestrial gravity.

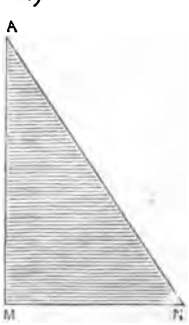


Fig. 6.

12. Let the line A G, fig. 7, represent the *time* of a body's fall, and let this line be divided into equal parts, A B, B C, C D, D E, E F, F G, which shall express the seconds of the body's fall; the horizontal lines will then represent the velocity of the body at the corresponding times. The line B H expresses the *velocity* at the end of the 1st second; C I the velocity at the end of the 2nd second; and so on to G N, which expresses the velocity at the end of the 6th second. The little triangle, A B H, will then represent the space passed over in the 1st second; the four-sided figure, B C I H, will represent

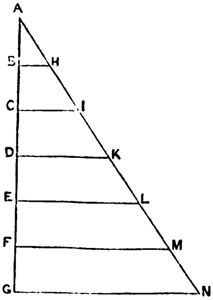


Fig. 7.

the space passed over in the 2nd second; and each of the succeeding four-sided figures will represent the space passed over in the single second to which it corresponds; the figure F M G N thus representing the space passed over in the 6th second.

13. I must here caution you against confounding the space passed over in the 6th second with the space passed over in 6 seconds. The latter space is evidently formed by adding all the spaces passed over in the 6 single seconds together; in other words, the space passed over in 6 seconds is represented by the triangle A G N.

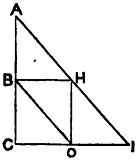


Fig. 8.

14. RELATION OF TIME AND SPACE.—We will now compare the spaces passed over in the single seconds with each other; and to render the process more simple, we will at present confine ourselves to the first two seconds. Draw the line H O, fig. 8, parallel to A C, and join the points B O. It is perfectly evident that the triangle B H O is equal to the triangle H O I, and also equal to B C O; or, in other words, the three triangles into which the second space is divided are equal to each other. It is just as plain that the triangle B H O is equal to A B H, for the line B H divides the four-sided figure A B H O into two equal parts; hence, we conclude that the space described by a falling body in the 2nd second of its fall, is exactly *three times* the space passed through in the 1st second.

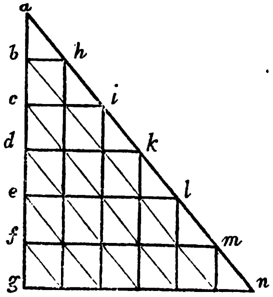


Fig. 9.

And if, by following out the process just described, we divide our whole triangle into a number of smaller ones, as in fig. 9, each equal to *a b h*, the mere inspection of such a triangle will show us that the space passed over in the 3rd second is *five times* the space passed over in the 1st; that the space passed over in the 4th second is *seven times* that passed over in the 1st; that the space of the 5th second is *nine times* that of the first; and the space of the 6th second *eleven times* that of the first. Hence, we arrive at the important conclusion that the spaces described in the succeeding seconds increase in the ratio of the odd numbers 1, 3, 5, 7, 9, 11, 13, &c. &c.

15. We shall now consider the spaces passed over, not in the seconds taken singly, but in any number of them taken together.

If the space passed over in the first second be = 1
then the space in the 2nd second will be = $1+3=4$
" 3 " = $1+3+5=9$
" 4 " = $1+3+5+7=16$

and thus we might proceed for any number of seconds.

Ranging the times in one column and the spaces in another, we shall find that we have arrived at a remarkable and most important result.

$$\begin{array}{cc}\text{Times.} & \text{Spaces.}\end{array}$$
$$\left.\begin{array}{cc} 1 & 1 \\ 2 & 4 \\ 3 & 9 \\ 4 & 16 \\ \&\text{c.} & \&\text{c.} \end{array}\right\} \;.\;.\;.\; \text{A.}$$

A glance at these figures will show us, that if we call the space passed over in the 1st second 1, the spaces are equal to the *squares of the times.* Thus, the square of 1 = 1, the square of 2 = 4, the square of 3 = 9, and so on.

16. But we must now be more precise. We have supposed the space passed over in the 1st second to be 1 merely for the sake of simplicity; the actual space passed over must, of course, be determined by experiment; and from the most exact experiments it has been ascertained that the space passed over by a body during

the 1st second of its fall amounts to a little more than 16 feet; the fraction above 16 is small, and, to facilitate our calculations, we will neglect it.

17. We now come to real practice. Referring to fig. 9, it is evident that, no matter what the space passed over in the 1st second may be, the space passed over in the 2nd second will be *three times* as much, in the 3rd second *five times* as much, and so on. Hence, if we multiply the series of odd numbers already formed by 16, we shall find the spaces actually passed over by a falling body, during the successive seconds of its fall. These spaces are—

$16 \times 1 = 16$
$16 \times 3 = 48$
$16 \times 4 = 64$
$16 \times 5 = 80$
&c. &c.

It is also evident that, as we have increased the area of each little triangle from 1 to 16, the whole space passed over in any number of seconds will be 16 times what we have found it to be in the table marked A, p. 333. The spaces will be no longer *equal* to the squares of the times, but *proportional* to the squares of the times. The space passed over in 3 seconds, for example, will not be 9, but 16 times 9; the space passed over in 6 seconds will not be 36, but 16 times 36. Hence the following important practical rule, where it is desired to find from the time of its fall the space through which a body has fallen:—

18. *Multiply the square of the time in seconds by* 16, *the product is the space passed through in feet.*

By means of this simple rule we can solve a great number of interesting questions.

Example 1. A stone let fall from the top of the spire of Salisbury Cathedral is 5 seconds in reaching the bottom: required the height of the spire.

$5^2 = 25$
$25 \times 16 = 400$ feet.

Example 2. An engineer requiring to know the depth of a coal-shaft, and having no string to measure it, let a stone fall into the shaft, and observed that it required 4 seconds to reach the bottom; required the depth of the shaft.

$$4^2 = 16$$
$$16 \times 16 = 256 \text{ feet.}$$

It may be remarked that the writer himself was once in the position here supposed, and found the knowledge of the rule which we are now discussing extremely useful to him.

19. If the problem be reversed, and the *space* be given to find the *time*, we must, of course, reverse our calculation. Supposing we have the height of Salisbury spire given = 400 feet, the time of a body's descent would be found as follows:—

$$\frac{400}{16} = 25$$
$$\sqrt{25} = 5 \text{ seconds.}$$

or, expressed in words,—

20. *Divide the given space by* 16, *and extract the square root; the quotient will be the time in seconds.*

Example 3. A stone is cast from a boy's hand vertically upwards and returns again to his feet; the time occupied by the stone on its journey up and down is six seconds. To what height did it rise?

In this case the stone, as it ascends, moves with a uniformly *retarded* velocity, finally comes to rest, and then returns upon its path. It descends with a uniformly *accelerated* velocity, the same time being occupied in the descent as the ascent. Hence, the problem resolves itself into this one: given the time of a body's descent three seconds, required the space through which it has fallen:—

$$3^2 = 9$$
$$9 \times 16 = 144 \text{ feet,}$$

which is the height to which the stone has ascended.

21. Relation of Time and Velocity.—In these examples we have confined ourselves to the relation

between the space and time. We shall now endeavour to obtain a clear notion of the law by which the *velocity* is regulated.

Let the line A G, fig. 7, represent, as before, the time divided into seconds; the line B H then represents the velocity at the end of the 1st second; the line C I represents the velocity at the end of the 2nd second; but it is evident that the line C I is double of the line B H, or, in other words, that the velocity at the end of the 2nd second is *double* of the velocity at the end of the 1st. In like manner, the velocity at the end of the 3rd second is *three times*, at the end of the 4th second *four times*, at the end of the 5th second *five times*, and at the end of the 6th, *six times* the velocity at the end of the 1st second; that is to say, the velocity increases in the same ratio as the time, or is proportional to the time.

22. If, then, we know the velocity at the end of the 1st second, the velocity at the end of any other second may be easily found. But here it is of the utmost importance that we should have a perfectly clear notion of what is now intended to be expressed by the word *velocity*. Supposing at the end of the 1st second, the action of gravity to cease suddenly, the body would move forward with the velocity which it had acquired at the end of the 1st second; but this velocity would be no longer accelerated; it would be *uniform*, for the continuous pull which causes the acceleration would be absent. Thus the velocity which a falling body possesses at the end of any time is the velocity with which it would proceed uniformly, supposing the action of gravity to cease at that particular time.

23. Now, as before observed, the space described by a body moving at a uniform velocity is represented by a rectangle, one of whose sides denotes the time, and the other the velocity. The little rectangle *b c h p*, fig. 10, therefore, represents the space passed over by a body moving with the uniform velocity *b h*, during the time *b c*. But *b c* represents one second, and *b h* is the velocity

at the end of the 1st second; consequently the rectangle, *b c h p*, is the space through which the body would move in the 2nd second, if the action of gravity were to cease at the end of the 1st. But *b c h p* is equal to twice the triangle *a b h*, and since *a b h* represents the number 16, *b c h p* will represent the number 32; it is, therefore, proved, that supposing the force of gravity to cease at the end of the 1st second, the body would possess a velocity sufficient to carry it, in the next second, through a space of 32 feet; in other words, it would possess a velocity of 32 feet a second.

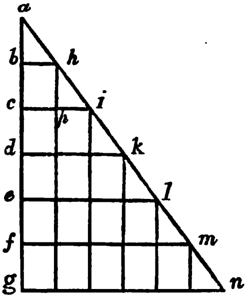


Fig. 10.

I know that boys usually find a difficulty in distinguishing the space passed over in the 1st second from the velocity acquired at the end of the 1st second. It must be remembered that, in the 1st second, the body commences falling from a state of rest, and gradually increases in velocity; that, in fact, the first 16 feet are not described at any particular velocity, but at all velocities from 0 to 32. Now, when a velocity is said to amount to a certain distance per second, it is a *uniform* velocity which is always meant, and it would, therefore, be totally erroneous to say that the body moves through the 1st second of its fall with a velocity of 16 feet a second; these 16 feet are, on the contrary, the space described on the 1st second by the body moving with velocities gradually increasing from 0 to 32.

24. We must, then, regard the line *b h* as denoting the number 32; but here it may be demanded, how is it that the line *b h* must be regarded as 32, when a moment ago it was stated that the space *b c h p* is 32? Both statements, however, are perfectly consistent with each other; for, the side *b h* being 32, and the side $b\,c = 1$, as

we suppose it to be, the area of the little rectangle will be $1 \times 32 = 32$.

In like manner the base *b h* being 32, and the height $a\ b = 1$, the area of the triangle *a b h* is 16, as it ought to be. We must not forget that the sides of a triangle or a rectangle are expressed in units of length, whereas the area is expressed in units of surface; and, in our case, the units of length express *time* and *velocity*, while the units of surface express *space*.

25. It being thus established that the velocity at the end of the 1st second is 32 feet, the velocity at the end of any given time may, as before shown, be found by multiplying the given time by 32: thus, the velocity at the end of 3 seconds is 96; at the end of 6 seconds it is 192; at the end of 10 seconds it is 320, and so on. If the velocity be given, we find the time necessary to produce it by dividing the velocity by 32. Thus, for example, a velocity of 320 feet a second requires 10 seconds' action to produce it, a velocity of 384 feet a second requires 12 seconds, and so on.

Example 4. How many seconds must a body fall to acquire the velocity of a 24-lb. cannon-ball, which, according to the table at page 312, is 2400 feet a second?

$$\text{Here } \frac{2400}{32} = 75 \text{ seconds.}$$

Example 5. Through what *space* must a falling body pass, in order to acquire the velocity mentioned in the last question?

When the time is given, it has already been shown that the space is found by multiplying the square of the time by 16; hence, finding the time as in the last question, the rule referred to may be applied:—

$$75^2 = 5625.$$
$$5625 \times 16 = 90{,}000 \text{ feet.}$$

JOHN TYNDAL.

LIFE OF FERGUSON.

BY GEORGE CRAIK.

LESSON I.

1. THE account which JAMES FERGUSON, the self-taught mechanician and astronomer, has left us of his own life would, even if it were nothing more, be one of the most interesting stories ever told; but such a narrative of successful endeavour in the face of great obstacles and disadvantages is always good for much more than the entertainment it affords us. It is, besides, an example, a lesson, and an encouragement. In addition to the chance hints which we may get from it, what may be called the air it breathes is cheering to the heart and tends to brace and strengthen our whole moral nature. Even when we have nothing to contend with in our own case of the same kind with the adverse circumstances surmounted in the biography, we yet feel as if we had a personal concern in the matter, and are the better for so feeling, while we follow the living, speaking demonstration which shows us how a fellow-man has been able, by earnest and resolute striving, to do battle with whatever opposed his onward progress, and to triumph over it.

2. Some of us may be compared, in the circumstances amid which we are born and reared, to the carefully-tended flowers of our gardens; others, almost to the wild-flowers that spring up by the wayside. Ferguson's lot was in the latter class. His father was a cottier, or farmer of the humblest description, in the north of Scotland, cultivating with his own hands the few acres of land which he rented. The spot was in Banffshire, some miles from Keith, which is now a considerable town, but was then only a small village. Here our hero, for so he may be called, was born in the year 1710.

3. He seems to have been one of the youngest of several

children. While his father was teaching his elder brother to read the Scotch Catechism, he sat listening, but saying nothing, and without being suspected of attending to what was going on. "Ashamed," he says, "to ask my father to instruct me, I used, when he and my brother were abroad, to take the catechism, and study the lesson which he had been teaching my brother; and, when any difficulty occurred, I went to a neighbouring old woman, who gave me such help as enabled me to read tolerably well before my father had thought of teaching me. Some time after, he was agreeably surprised to find me reading by myself; he thereupon gave me farther instruction, and also taught me to write." And this, he adds, with about three months that he was

some time after put to school at Keith, was all the education he ever received,—all, he means, that he did not pick up for himself.

4. It would seem to have been after he had acquired the art of reading in this stealthy way that the circumstance occurred which, he conceives, first awakened his taste for mechanics. He was about seven or eight years old, when, a portion of the roof of their cottage having decayed and sunk down, his father, in order to raise it to its former position, applied a prop and lever to one of the beams: to the boy's amazement, the ponderous roof rose as if it had been of inconsiderable weight. His first impression was that his father's strength must be something far transcending what he had ever before thought it; and this notion, he says, filled him with as much terror as wonder. But one material circumstance had not escaped his close observation—thinking further of the matter, he began to reflect that his father, in proceeding to raise the roof, had applied his strength or weight to that part of the lever which was farthest from the prop. It struck him that herein lay the secret of the effect produced; and on inquiring of his father he found that he was right. He had now got as it were possessed of, or by, a grand central and productive idea; he forthwith set to making levers (which he called bars) with great eagerness; and he soon found, by applying weights to them in different ways, that, as he had conjectured would be the case, the power of the bar in lifting a weight varied exactly according to the distances of the weight to be raised and that of the applied force from the prop. He proceeds: "I then thought it was a great pity that, by means of this bar, a weight could be raised but a very little way. On this, I soon imagined, that, by pulling round a wheel, the weight might be raised to any height by tying a rope to the weight, and winding the rope round the axle of the wheel; and that the power gained must be just as great as the wheel was broader than the axle was thick; and found it to be exactly so, by hanging one weight to a

rope put round the wheel, and another to the rope that coiled round the axle."

5. The contrivance which the boy had thus struck out was that application or extension of the principle of the common lever which goes by the name of the "wheel and axle," and by which the force applied is enabled to raise the weight to any height allowed by the length of the ropes employed. This is far from being one of the simplest or most obvious of mechanical arrangements, and that it should have suggested itself to one so young, even after a knowledge of the lever had been acquired, is sufficiently extraordinary. It shows, at any rate, how thoroughly—owing probably in great part to the practical and experimental way in which his knowledge had been gained—the original principle had been apprehended and mastered.

6. He goes on to state, that, by means of a turning-lathe which his father had, and occasionally used (this and other facts which have been mentioned indicate that the father must have been a person not only of superior general intelligence, but endowed with something of the same mechanical turn which so early and in so remarkable a manner developed itself in the son), and with a little knife, he was enabled to fashion the wheels and other parts of his different machines.

7. It had now, however, become necessary that he should begin to do something to relieve his father from the charge of his maintenance; so, being thought to be rather too young and weak for hard labour, he was hired out to a neighbour to be employed in looking after his sheep; and in this service he continued for some years. It was now that, while he amused himself in the daytime by making models of mills, spinning-wheels, and other such mechanical contrivances as he happened to see, he began to study the stars when night, wrapping the earth in obscurity, unveiled the mechanism of the heavens. The way in which he proceeded, without help of book or teacher, prompted only by his thirst for knowledge, and guided by his own ingenuity, affords

a curious and instructive specimen of what might be termed *natural* philosophy in a double sense. Before he had gone far with his astronomical studies, he was promoted from his post of shepherd boy to that of general labourer in the service of a farmer of a higher class. This man, James Glasham, is well entitled to have his name recorded wherever Ferguson's history is told. "I found him," the latter writes, "very kind and indulgent; but he soon observed that, in the evenings when my work was over, I went into a field with a blanket about me, lay down on my back and stretched a thread, with small beads upon it, at arm's length between my eye and the stars, sliding the beads upon it till they hid such and such stars from my eye, in order to take their apparent distances from one another; and then, laying the thread down on a paper, I marked the stars thereon by the beads, according to their respective positions, having a candle by me. My master at first laughed at me, but, when I explained my meaning to him, he encouraged me to go on; and, that I might make fair copies in the day-time of what I had done in the night, he often worked for me himself. I shall always have a respect for the memory of that man!" One day, having been sent with a message to the house of Mr. Gilchrist, the clergyman of Keith, he took his "star-paper" with him to show to that gentleman, to whom he had been known from his childhood. The clergyman happened at the time to be employed in looking over some maps; they were the first that Ferguson had ever seen. It was now, too, he intimates, that he first learned that the earth was round like a ball. Mr. Gilchrist told him this, at the same time explaining to him the map of the two terrestrial hemispheres; and when he asked to be allowed to take it away that he might make a copy of it, not only let him have it, but supplied him with pens, ink, paper, a ruler, and a pair of compasses, to assist him in his task. Nor did his good kind master fail to perform his part: he "often," Ferguson gratefully relates, "took the threshing-flail out of my hands and worked himself, while I sat by him in the barn, busy with my compasses, ruler, and pen."

8. When the map was done, it was arranged that he should take it to Mr. Gilchrist. His master gave him permission, besides the time necessary for the journey, to stay two hours to converse with the minister. This expedition had results of some importance. At Mr. Gilchrist's he met a country gentlemen, Mr. Grant, of Achoynanly, who, upon examining his map, was so much pleased with the performance, that he not only invited the boy to come and stay with him, but even offered to procure a substitute who should take his place for the rest of the time that he was engaged to his present master, that he might get away immediately. Ferguson, however, thought it right to remain where he was for the present. But "when the term of my servitude was out," he continues, "I left my good master and went to the gentleman's house, where I quickly found myself with a most humane, good family." His great friend here was the butler, Mr. Cantley, whom he describes as the most extraordinary man that he ever was acquainted with. Ferguson had already taught himself common arithmetic from books, and Cantley immediately began to instruct him in decimals; after which they proceeded to algebra, and from that to the elements of geometry; but they had just entered upon this last branch when the learned butler was induced to exchange the service of Mr. Grant for that of a nobleman at some distance, to the inexpressible grief of his young friend. He took the loss of his teacher so much to heart, that the family could not prevail upon him to remain with them any longer, and he returned to his father's.

9. Cantley had made him a present of a book, which, he says, was at the time a great treasure to him. This was the system of geography then in common use, entitled Gordon's "Geographical Grammar." Here Ferguson found an account of the globes and their use; and, although it was not illustrated by figures, and he had never seen a globe, he thought he could make one

after the description. So he set to work, and, having turned a ball out of a block of wood, and covered it with paper, he proceeded to draw the map of the world upon it; then he made the meridian ring and the horizon, both of wood, covering them, too, with paper, and graduating them. It cost him the labour of three weeks to do all this, but, when his handiwork was finished, he had the satisfaction to find that it really was a globe, and that he could solve all the problems by it.

10. This kind of work, however, instructive and also pleasant as it might be, could hardly be depended upon as a means of living; so the boy now went into the service of a miller, thinking that the mill would be comparatively light work, and that he would have "a great deal of leisure time," as he says, "to study decimal arithmetic and geometry." But this vision proved quite delusive. The miller, partly perhaps from finding that his servant could be so completely relied on, spent most of his time in the alehouse, leaving Ferguson to take charge of everything; and, while the one was thus soaking himself with beer, the other often had nothing to eat, so that he was glad, he says, when he could get a little oatmeal mixed with cold water to satisfy his hunger. This miserable life he led for a whole year, his engagement being for that term. He then returned once more to his father's, in a very weak state of health. But his next adventure was still more disastrous.—Having after some time recovered his strength, he was induced to engage himself as a labourer in the service of a Dr. Young, whom he describes, somewhat oddly, as "a neighbouring farmer, who practised as a physician." He did this by the advice of his father, on the farmer promising to instruct him in the medical part of his business. "But instead of performing his promise," says Ferguson, "he kept me constantly to very hard labour, and never once showed me one of his books." The result was that, although his engagement was for half a year, he was obliged to leave at the end of three months, quite worn out, and suffering besides from an

accident which had deprived him for some time of the use of his left arm. He lay ill for two months at his father's, despairing of ever recovering the use of his arm.

LESSON II.

LIFE OF FERGUSON—*continued.*

1. NOTHING could stop his working mind. It was while he was in this low state that the idea seized him of trying to make a clock; and he succeeded. He constructed it all of wood, the works as well as the frame or case. The only part that is mentioned as having been of another material was the bell on which the hours were struck; it was the neck of a broken bottle. Whether the hammer was of wood or of metal is not stated.

2. The next incident which he records must be related in his own words; the account is too graphic as it stands to admit of curtailment or alteration. "Having then," he continues, "no idea how any time-keeper could go but by a weight and line, I wondered how a watch could go in all positions, and was sorry that I had never thought of asking Mr. Cantley, who could very easily have informed me. But happening one day to see a gentleman ride by my father's house (which was close by a public road), I asked him what o'clock it then was. He looked at his watch and told me. As he did that with so much good-nature, I begged of him to show me the inside of his watch; and, though he was an entire stranger, he immediately opened the watch and put it into my hands. I saw the spring-box with part of the chain round it, and asked him what it was that made the box turn round. He told me that it was turned round by a steel spring within it. Having then never seen any other spring but that of my father's gun-lock, I asked how a spring within a box could turn the box so often round as to wind all the chain upon it. He answered that the spring was long and thin, that

one end of it was fastened to the axis of the box and the other end to the inside of the box,—that the axis was fixed, and the box was loose upon it. I told him I did not yet thoroughly understand the matter. Well, my lad, said he, take a long thin piece of whalebone, hold one end of it fast between your finger and thumb, and wind it round your finger, it will then endeavour to unwind itself; and if you fix the other end of it to the inside of a small hoop, and leave it to itself, it will turn the hoop round and round, and wind up a thread tied to the outside of the hoop." This was enough. Ferguson thanked the gentleman, and told him that he now understood the thing perfectly. This curious relation evinces in every line of it the remarkable intelligence of the boy, and is quite an instructive model in the art of questioning for the purpose of acquiring information. And along with the clear-headedness and ingenuity which the questions display, let us by no means fail to take note of the honesty of mind which he showed throughout, and the moral courage, never pretending to understand the explanation given him till he really did so, or attempting to conceal either his ignorance or what he might have been afraid would appear his slowness and dulness of apprehension, as many another boy or man in the same circumstances would have done.

3. As usual, the young philosopher immediately proceeded to turn to account with his hands the knowledge which he had got into his head. He set about making a watch with wooden wheels and a spring of whalebone; and although he found that it would not go when the balance was put on, from the teeth of the wheels being rather too weak to bear the pressure of so strong a spring as was required to move the balance, yet the wheels went fast enough when the balance was taken off. This was quite enough to test the principle. He had produced what was essentially a watch, though but a rude or rudimentary one. He finished his work by enclosing the whole mechanism in a wooden case, which

he says was only a little bigger than a breakfast tea-cup. "But a clumsy neighbour," the story concludes, "one day looking at my watch, happened to let it fall, and, turning hastily about to pick it up, set his foot upon it and crushed it all to pieces, which so provoked my father that he was almost ready to beat the man, and discouraged me so much that I never attempted to make such another machine again, especially as I was thoroughly convinced I could never make one that would be of any real use." It would have been impossible, certainly, with the materials and instruments he had at his command.

4. Soon after this the ingenious and persevering boy attracted the notice of a neighbouring gentleman, Sir James Dunbar, of Durn, under whose patronage he made a little money by going about the country cleaning clocks. From this he proceeded, on the suggestion of Sir James's sister, Lady Dipple, to draw patterns for needlework, which he found a good deal more productive; so that he had the pleasure, he tells us, of occasionally out of his earnings supplying the wants of his poor father. "Yet all this while," he adds, "I could not leave off star-gazing in the nights, and taking the places of the planets among the stars by my before-mentioned thread."

5. He now also took to a new art. Sir James's house was full of pictures and engravings, and Ferguson, who never neglected an opportunity, copied several of them with pen and ink, and so taught himself the elements of painting. It was not long before he was able to take likenesses; and he found, he says, that "it was much easier to draw from the life than from any picture whatever, as nature was more striking than any imitation of it." He was afterwards taken to Edinburgh by Lady Dipple, and through her patronage and that of her friends, was enabled to obtain considerable employment as a portrait-painter. He soon had as much to do as he could manage, and so was enabled, he states, not only to put a good deal of money into his own pocket,

but to spare something to supply the wants of his father and mother in their old age.

Portrait-painting, in fact, was the profession which he followed, and by which he chiefly maintained himself for the next six-and-twenty years. Yet he never, he tells us, gave himself heartily to it, or strove much to excel in it; his mind kept still running after its first studies, astronomy and mechanical contrivance. At one time, too, he was seized with a violent inclination to become a doctor—the revival of another early dream, which had once already involved him in difficulties. He even went so far, after reading some works on anatomy, surgery, and physic, as to leave Edinburgh, when he had been only two years there, and, taking with him a quantity of medicines, plasters, and other things of the kind, to repair to his native district, with the view of setting up there as a medical practitioner.

6. He still, however, kept up his astronomical studies, and he gives some interesting details of some ingenious investigations in this department, with which he occupied himself while moving about from place to place in his occupation of portrait-painter. He was never idle; either head or hand was always at work, oftener both together. It was in the year 1739, when he would be about thirty years of age, that he completed a scheme, or diagram, for showing the eclipses of the sun and moon throughout the lunar cycle, which he called the Astronomical Rotula, and soon after had it engraved and published. It continued to sell very well till it was rendered useless by the change of style in 1752. But the circumstance that most influenced his future course was his being made known to the celebrated mathematician, Professor Maclaurin, of the University of Edinburgh. An orrery, or contrivance for showing the movements of the heavenly bodies, which Maclaurin had, combining, as it did, his two favourite sciences of astronomy and mechanics, completely enchanted him. He was not long in making one like it for himself; and in course of time he became

very celebrated for the construction of such instruments, into every one of which he produced, he always introduced something new.

7. At length, in May 1743, he determined to go to London. Four years before this he had married. Painting portraits was what he still depended upon for his livelihood; but a positive addition which he made to astronomical science, by showing that the motion of the moon in going round the earth is always concave towards the sun, in no long time placed him in a new position. In the year 1747, he published his first literary work, "A Dissertation on the Phenomena of the Harvest Moon." Ferguson's style, simple and clear, and always reflecting that perfect conception of every part of his subject from which it flowed, was admirably adapted for scientific exposition; it was always, at least, that of a person both of sound knowledge and of good sense. His superiority to every kind of pretension and affectation abundantly made up for any deficiency of literary training which may have been perceived in him, and which, indeed, was best kept out of view by no elaborate effort being made to hide it; while, at the same time, his method of always expressing himself as naturally as he could preserved him from the worst faults into which imperfectly-educated writers are apt to fall.

8. In 1748 Ferguson first appeared as a lecturer. His subjects were mechanics, hydrostatics, hydraulics, pneumatics, electricity, and astronomy; and his success was so decided that he now entirely gave up portrait-painting. "It is now thirty years," he concludes, in his biographical sketch, "since I came to London; and during all that time I have met with the highest instances of friendship from all ranks of people, both in town and country, which I do here acknowledge with the utmost respect and gratitude; and particularly the goodness of our present gracious sovereign, who, out of his privy purse, allows me fifty pounds a-year, which is regularly paid without any deduction." George the Third, before

he came to the throne, used sometimes to honour the lecturer with his presence; and Ferguson, in after-years, was frequently sent for by their Majesties to St. James's and Kew. In 1763 he was admitted a Fellow of the Royal Society. He died on the 16th of November 1776, leaving property to the value of upwards of six thousand pounds.

Astronomy.

WHAT WE SEE IN THE HEAVENS.

BY ROBERT MAIN.

LESSON I.

> "The Heavens declare the Glory of God, and the firmament showeth his handywork."

1. **Astronomy** is the science which teaches us the nature and the movements of the heavenly bodies.

It is the noblest of all the physical sciences, because of the grandeur of the objects with which it makes us acquainted, and because it separates us so completely from the petty cares and concerns of our present exist-

ROYAL OBSERVATORY, GREENWICH

ence, and forces upon our notice the noblest and most wonderful works of our Creator. It is also one of the most exact and most useful of the sciences. By its aid, in connection with mathematics, we are enabled to predict with certainty, for thousands and tens of thousands of years, the places and the mutual relations of the bodies which are nearest to us and which most concern us, and also to know in some cases, and to guess in others, the nature and distances and laws of distribution of those other bodies which are so remote that ordinary numbers almost fail us when we try to realize their positions with regard to our world.

"How beautiful
Must be the work of nature to a child
In its first fresh impression! Laura stood
By the low window, with the silken lash
Of her soft eye upraised, and her sweet mouth
Half parted with the new and strange delight
Of beauty that she could not comprehend,
And had not seen before. The purple folds
Of the low sunset clouds, and the blue sky
That looked so still and delicate above,
Filled her young heart with gladness, and the eve
Stole on with its deep shadows, and she still
Stood looking at the west with that half smile,
As if a pleasant thought were at her heart.
Presently, in the edge of the last tint
Of sunset, where the blue was melted in,
To the first golden mellowness, a star
Stood suddenly. A laugh of wild delight
Burst from her lips, and putting up her hand,
Her simple thought broke forth expressively,
"Father, dear father, God has made a star!"

2. But it not only gratifies our curiosity and stimulates our mental powers, but it is of vital importance to us in our daily business and in our commercial as well as ordinary affairs. By its aid we regulate our clocks and watches, and divide the day into its hours allotted for rest and for labour, for business and for recreation. By its aid, too, we learn to regulate our business throughout the year; seed-time and harvest are foreseen and provided for, and the dark days and inclement skies of winter do not take us unawares. Finally, by means of it,

ships are enabled to cross with safety the trackless ocean, and to reach their distant port with infallible accuracy.

To gain a perfect acquaintance with the wonders of the heavens requires not only great patience and skill, but great learning and research; but to gain a moderate and instructive knowledge of its principles is open to every one with ordinary intelligence and ordinary powers of observation.

3. Let us suppose that on a fine winter's night we are watching the appearance of the heavens. High up in the boundless firmament, and on every side of us, there are countless multitudes of stars. At first we are dazzled and perplexed by their numbers and brilliancy, but an attentive study of them for even one evening will teach us a great deal concerning them.

First, then, the greater number of them are fixed, or so nearly so, that in a long series of ages, since the creation of man for instance, there has been no sensible difference in their relative positions. Hence with a tolerably good eye we may mark down their positions on a map prepared like those used for geographical purposes. The only difference is that the surface of the earth is that of a *convex* sphere, while we are looking into a *concaves* phere up at the celestial objects we wish to record. Instead of making a map for ourselves, however, it will be better for our purpose to use one of those which have been already made by astronomers. Such maps are constructed on a similar principle to terrestrial maps, and refer the places of the heavenly bodies to similar fixed circles, the notion of which is derived from the rotation of the earth on its axis.

4. We may stop to inquire how we know that the earth rotates on its axis, and a single night's observation of the heavens will convince us of the fact. If we turn our eyes to the east, and watch the stars, we shall observe that they are constantly rising higher in the heavens, and that new ones are always coming into view, while in the west they are getting lower, and those nearest the horizon one after the other become invisible. If our

face is turned towards the south we shall find this motion, or *set*, of all the stars in the same direction from east to west, going on with considerable rapidity; but if we turn towards the north we shall soon perceive that it is very much smaller, and that at a particular point, marked by a tolerably bright star, (called the Pole Star,) there is absolutely no motion perceptible to the naked eye.

We shall also soon discover that the motions of all the stars are in parallel planes; and putting all these facts together, and considering that the stars are all found in pretty nearly the same situations on the next evening, and that their relative situations have always remained the same, we must come to the conclusion, either that the whole mass of stars moves together round a fixed imaginary line passing through the earth, or that the earth rotates uniformly round a fixed axis. The first supposition any one of ordinary intelligence would at once reject as extremely improbable; and it follows that the earth on which we live, moves in the direction contrary to the apparent motion of the stars, that is, from west to east.

5. The imaginary line round which the earth revolves passes through the earth's centre, and is called the axis of the earth, and when produced cuts the sphere of the heavens in the points called the *north* and *south poles*. A plane passing through the earth's centre perpendicular to the axis will cut the sphere of the heavens, as also the surface of the earth, in two circles, called the *celestial* and the *terrestrial equator*. Finally, if we imagine a plane drawn through our position on the earth's surface and touching it, and another through the earth's centre parallel to it, these are called respectively the *sensible horizon* and the *rational horizon*.

6. Let us now return to our celestial map, with a better chance of understanding its representation of the heavens. We shall find the stars laid down with reference to the poles and the equator, and in addition several circles passing through the poles similar to the meridians or circles of longitude on a terrestrial globe,

and certain small circles parallel to the equator, similar to the circles of latitude on a terrestrial globe, and answering the same purpose, namely, to measure the angular distances of the stars from the equator.

The circles passing through the poles we shall find to be twenty-four in number, corresponding in fact to the twenty-four hours into which the natural day is divided, and these circles serve to estimate the distances of the stars from a determinate point of the equator, the distances thus measured being called their *right ascensions*. If we could observe by means of a clock, whose hour-hand describes exactly twenty-four hours in the interval between the time of a star leaving any meridian and returning to it again, the time at which this fixed point passes a meridian, and also the time at which a star passes the same meridian, then the difference of these times would be the right ascension of that star. In practice, however, the clock is supposed to denote $0^h\ 0^m\ 0^s$ when this fixed point is on the meridian, and then its indications give immediately the right ascensions of objects observed. A clock thus regulated is said to keep *sidereal time*.

7. The angular distances from the equator, measured each way, are called respectively *north* and *south declinations*; or if the distances be measured along the polar circles from the north or the south pole (which is far preferable), they are called *north* or *south polar distances*.

The right ascensions might be measured from *any* point on the equator, supposing that the point were fixed and its position known, just as the longitudes of places on the surface of the earth are measured by astronomers of different nations from different first meridians; but in practice they are measured from a point technically called the *first point of Aries*. The position of the point we cannot otherwise define at present than by saying that it is situated where the sun is found on entering the *vernal equinox*. We shall have occasion to recur to the consideration of it again when we treat of the seasons.

8. If we keep in mind the principles of the arrangement of the stars which have been explained, something like order will begin to be evident to the mind of the student, and he will be prepared to classify and to arrange in their proper places the bewildering multitudes of stars which at a first glance puzzle and perplex him. But before he can have a perfectly correct idea of the geometrical relations of the heavenly bodies, he will still have two additional points to take into consideration. The first of these is the point of the earth's surface at which he is situated, and the second is the season of the year at which his review of the heavens is made.

9. The figure of the earth is, strictly speaking, spheroidal, that is, a line drawn from the centre to either of the poles is shorter by $\frac{1}{300}$th part than a line drawn from the centre to any point of the equator. It is sufficient for ordinary purposes, however, where very great accuracy is not required, to consider it to be a perfect sphere, that is, exactly like an ordinary globe. Let us imagine ourselves to be at Greenwich, that is in latitude 51° 29′ north. Now, since this latitude represents the arc between the earth's equator and the place of observation, and that the celestial equator is nothing more than the earth's equator produced to the heavens, and the point over head, technically called the *zenith*, is in the prolongation of the line drawn from the centre to the place of observation, it is quite plain that the *zenith of the place of observation* is distant from the celestial equator by the amount of the latitude, or by 51° 29′, and, therefore, that the pole of the heavens (distant 90° from the equator) is at the same distance from the north horizon. Hence we arrive at this important proposition, that the *altitude of the pole is equal to the latitude of the place of observation.*

It is also equally clear that, if we draw a great circle through the pole and the zenith, and produce it to meet the south horizon, the arc of it between the equator and the zenith, as also between the equator and the south horizon, is equal to the *colatitude of the place*, that is, to the latitude subtracted from 90°.

The great circle last mentioned, passing through the pole and the zenith, and produced to meet the north and south horizons, is called the *meridian of the place of observation.*

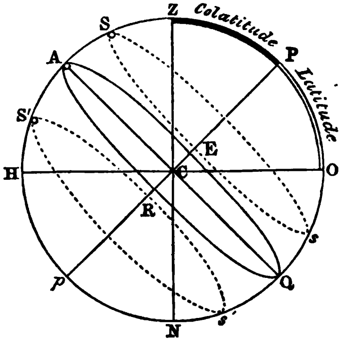
10. The student, then, who has mastered these few simple facts, will soon be able to get a correct notion of the position of these circles that have been described in the heavens, and hence will learn readily to find the bright stars in the maps whose positions are laid down with reference to them. Thus, if he look towards the north point, at an altitude of about 51°, he will readily find the Pole Star, which is tolerably bright and has no other stars near it within several degrees.

Imagine, then, the great circle which would pass through this star and the zenith, or point directly above, and this circle is the *meridian* nearly.

All stars on passing this circle come to their highest point above the pole, or to their lowest point below the pole, and are said to *culminate.*

Turn now to the south, and imagine the point on this circle where the sun is at noon on the 21st of March or the 23rd of September, that is, at the vernal and autumnal equinoxes, and this will be the *culminating point of the equator*, which, as it cuts the horizon exactly in the east and west points, can be easily traced in the mind.

To fix the ideas, it will be proper at this place to represent to the eye, by means of the annexed diagram, the relative positions of the circles which we have been describing.



Let H Z O N be a section of the celestial meridian through C, the centre of the earth; Z, the zenith of the place of observation; and N, the point opposite to it, called the *Nadir*; H O, a section of the horizon; P and *p*, the north and the south poles of the heavens; and A E Q R the plane of the equator at right angles to P *p*.

Then P O, the elevation or altitude of the pole, is equal to the latitude of the place, and Z P, between the zenith and the pole, to the colatitude; and these are plainly equal to Z A and A H, that is, to the zenith distance and altitude of the culminating point of the equator, respectively.

Also if S *s* and S′ *s*′ be respectively the apparent diurnal circles described by two stars parallel to the equator, one north of it and the other south, it will be evident that the northern star will be a longer time, and the southern star a shorter time, above the horizon, than below it, while a star on the equator will be twelve hours above and twelve hours below it.

* * *

THE POWER OF GOD.

Thou art, O God, the life and light
Of all this wondrous world we see;
Its glow by day, its smile by night,
Are but reflections caught from Thee!
Where'er we turn, thy glories shine,
And all things fair and bright are Thine.

When day with farewell beam delays
Among the opening clouds of even,
And we can almost think we gaze
Through golden vistas into heaven,
Those hues that mark the sun's decline,
So soft, so radiant, Lord, are Thine.

When night, with wings of stormy gloom,
O'ershadows all the earth and skies,
Like some dark beauteous bird, whose plume
Is sparkling with a thousand eyes,
That sacred gloom, those fires divine,
So grand, so countless, Lord, are Thine.

When youthful spring around us breathes
Thy spirit warms her fragrant sigh,
And every flower the summer wreaths,
Is born beneath that kindling eye:
Where'er we turn, thy glories shine,
And all things bright and fair are Thine.

MOORE.

LESSON II.

WHAT WE SEE IN THE HEAVENS—*continued.*

"Which maketh Arcturus, Orion, and Pleiades, and the chambers of the south."

1. THE next point for consideration is the effect of the season of the year, on apparent positions of the stars seen at the latest hour of the night. If we look at the heavens at midnight in January, and at the same hour in June, in the northern portion they will all have changed places, while towards the south a totally different set of stars will be presented to us.

No person capable of being affected by the wonders of the heavens will fail to call to mind the glorious vision which is presented to him a little before midnight on a night in January.

The grand constellation Orion is then near the meridian, and Sirius, the brightest star in the heavens, is glittering nearer the horizon towards the west. High in the heavens, and also approaching the meridian, are the stars Castor and Pollux, twins in lustre and position, while Procyon is easily recognised near the equator considerably below them. Still nearer to the zenith are Taurus and the Pleiades, and the grand circle called the galaxy, or milky way, is seen stretching its broad band of light across the sky. In this portion of the heavens the stars seem to be innumerable, densely crowded, from the first magnitude to that which the eye can barely distinguish, and leaving to the imagination the countless thousands which the telescope would reveal in this luminous region. Finally, Capella, the bright star of the constellation Auriga, shines in the zenith with brilliancy almost seeming to rival that of Sirius.

2. Let us now wait for six months, and resume our study of the sky at the end of June. None of the southern stars, with which we made so close an acquaintance in the winter, are now visible, but their places are occupied by others differently situated, and with totally different configurations.

Near the meridian, and crossing the equator, is the bright constellation *Aquila*, through which passes one branch of the milky way, both branches being glorious objects as they stretch across the southern sky. Near the zenith is α Lyræ, incomparably brighter than any other star now visible; and the harp-like shape of the constellation *Lyra* is easily recognised: the three principal stars of the Eagle, namely, γ, α, and β Aquilæ, suggest to us, with a little imagination, the outstretched wings of this noble bird in full career across the southern sky. Looking towards the west, one star, far brighter than any of the others, immediately attracts our attention. This star is Arcturus, the bright star in the constellation Bootes, and beneath these are the stars of *Corona* and *Serpens*. In the north will be seen the bright stars in Cepheus approaching towards the meridian not far from the zenith, while *Ursa Major*, which was on the east side of the pole in January, is now on the west side. Capella may now be seen near the north horizon, whereas in winter he was looking proudly down from the zenith, and the aspect of the heavens is as different as can be imagined.

3. We can readily explain this difference, by the introduction of a consideration which has not yet occupied us, namely, the apparent motion of the sun in the heavens. Hitherto we have spoken only of the *real* diurnal motion of the earth on its axis, as producing the *apparent* diurnal motion of the stars. Their glorious and orderly march from east to west, in one compact mass, is due to no real motions of their own, but is of the same motion as the successive presentation of objects on

different sides of a spectator, placed on a revolving platform, and unconscious of his own motion. The objects would appear to him to revolve, while he would fancy himself to be at rest. We have now, however, a phenomenon of real progressive motion to take into account; and this motion is put in evidence to us by the apparent motion of the sun, as we shall proceed to explain.

4. When we speak of day, we mean that the sun is above our horizon, and when we speak of night, we mean that he is considerably below it. Noon is regulated by the culmination of the sun, that is by his passage across the meridian, though it does not exactly coincide with it; and midnight by his passage across the opposite side of this same meridian, beneath the horizon. Hence, at midnight, the stars that are visible near, or on the south horizon, differ in right ascension from the sun by about twelve hours; and since, at the different seasons of the year, all the stars in orderly succession have come upon the meridian at midnight, it is plain that in the course of the year the sun has apparently made the circuit of the heavens. Since, also, the same star comes to the meridian earlier every evening, that is, seems to approach the sun in going from east to west, it is plain that the sun travels through the heavens from west to east.

5. But we may represent this, perhaps, more easily by another consideration. Let us, night after night, watch the position of a particular bright star soon after sunset, as it is descending towards its own setting in the west. After a few evenings we cannot fail to become aware that it is lower at the same hour of the evening; and at length it will be so near the horizon that we shall lose it altogether, being lost in the sun's rays after his setting. Now this cannot take place by reason of the star approaching the sun, but by reason of the sun approaching the star from west to east. Since this star will be found to present its relative position with regard to all the other stars unaltered. In the same manner, if we were up early in the morning before sunrise, and were to watch a star near the east horizon, we should find

that at the same hour in the morning it would by degrees be sensibly higher in the heavens, proving that the sun was moving away from it eastward. In the infancy of astronomy, indeed, such observations were those on which the regulation of the different seasons of the year was made to depend. Certain bright stars were selected, and the time at which each rose pretty nearly with the sun was roughly observed. This was called the *heliacal* rising of the stars, and served, in defect of better observations, to regulate the operations of agriculture.

6. The general fact then becomes abundantly evident that the sun has an apparent progressive motion from west to east, and that after a certain number of rotations of the earth on its axis, he comes back to his former position among the stars. The period of time in which this circuit is performed is called a *year;* and if we denote by this term the interval between his leaving a star and returning to it again, it is called a sidereal year. We must, however, carefully remember that this is not the period of time on which the seasons depend; and we are not yet in a condition to explain what period of time is denoted by this latter, which, for distinction, is called the *tropical* year.

7. We have said that the sun *appears* to move in the heavens; that he does not really move, but is fixed relatively to the planets, being the centre round which they all revolve, is known by any schoolboy. But all the phenomena with which we are concerned are explained equally well, whether we consider the sun to move round the earth or the earth round the sun; and in the ordinary language of astronomers, the sun, and not the earth, is supposed to move. All we are concerned with is the projection of his place as seen from the earth on the sphere of the heavens, or of the fixed stars supposed to be at an infinite distance, and the real motion of the earth from west to east produces an exactly equal apparent motion of the sun in the same direction.

8. It may be assumed, then, without scruple, that the

sun moves through the whole circle of the heavens in a period of time called a year; and by noting the stars near which he passes during the whole of that time, and marking the approximate positions on a celestial globe, it would be found that he moves in a *great circle;* that is, a circle whose centre is the same as that of the sphere of the heavens. The plane in which this motion is performed is called the *Ecliptic*, because it is that plane in which *eclipses* of the sun and moon must take place. The ancients divided this circle into twelve equal parts called the *Signs of the Zodiac*, each occupying, of course, $\frac{360}{12}^{\circ}$, or 30°; and these signs were named after the constellations into which the sun entered at certain seasons. The names of these signs are, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittarius*, *Capricornus*, *Aquarius*, *Pisces*. These in the early ages of astronomy indicated the seasons of the year, and do so even now, especially in some of the older almanacs. Thus when the sun enters Aries the spring quarter has commenced; Cancer denotes in like manner the beginning of summer, Libra of autumn, and Capricorn of winter.

9. Since the ecliptic and the equator are both *great circles*, that is, since both pass through the visible sphere of the heavens, their places will cut each other in a line, which is a diameter of the sphere. The two points of intersection of this diameter with the surface of the sphere are called respectively the *first point of Aries*, and the *first point of Libra*, but more generally the *equinoxial points*, because when the sun passes through these points the days and nights are equal throughout the globe. On the contrary, the first point of Cancer, and the first point of Capricorn, are called the solstitial points; the former being the time of the summer solstice, when the sun has his greatest northern declination, and, for northern latitudes, the days are longest; the latter, being the time of the winter solstice, when, for the northern latitudes, the days are shortest. The vernal and autumnal equinoxes, corresponding to the

entry of the sun into Aries and Libra occur about the 21st of March and the 23rd of September, and the summer and winter solstices, corresponding to his entry into Cancer and Capricorn, occur about the 21st of June and the 21st of December.—Robert Main.

Fine Arts.

LESSON I.

GIOTTO DI BONDONE.

BY R. N. WORNUM.

1. It was about the year 1286, when the great Florentine painter Cimabue had occasion to transact some business at Vespignano, a village among sunny hills about fifteen miles from the city, that he was surprised in his walk by seeing a little boy, ten years old, drawing a sheep on a stone. This was at a time when drawing was not

only the accomplishment of extremely few, but when the very profession of the arts was rare. Cimabue was the greatest painter of his time, and he is supposed to have been taught by some travelling Greeks from Constantinople, who were in the habit of wandering in search of decorative work of various kinds, as painting windows in the churches, executing mosaic work, or providing pictures of the saints for altar-pieces. These works were all executed in a uniform traditionary manner, which is termed Byzantine; the artist himself made no use of his individual judgment or taste, if he had any, but followed custom; and of course he always produced very bad pictures, for principles of beauty were interdicted strangers to his pursuit. Cimabue painted much in the style of these Byzantine Greeks, though not without some indication of an Italian influence. There were, however, some other Italian painters even older than Cimabue, who were very great masters for their time; of these one of the best was Giunta of Pisa, commonly called Giunta Pisano; he, too, was probably taught by Greeks, but he evidently studied nature for himself, and made great progress in drawing, as compared with the Byzantines; a crucifixion by him at Assisi, painted in 1236, is an admirable performance for its time. It was, however, this little boy discovered by Cimabue at Vespignano, that became the first really great painter of the moderns.

2. Cimabue was astonished at the power and originality of this untutored genius, who was an artist from pure natural impulse. The boy's name was Giotto, his father's name was Bondone, and his employment was to tend his father's sheep. This name Giotto is uncommon in Italy—so uncommon that it is still disputed whether it is a complete name, or only an abbreviation of the Italian forms of the names Ambrose and Roger; in the latter case it is of course a mere nickname, and nicknames are almost universal in Italy: he is called by the Latin writers of his time *Magister Joctus*, which is some evidence that Giotto was his true name.

3. The father willingly surrendered the boy into the hands of the great painter, and Giotto accompanied Cimabue to Florence, and at once entered upon the pupilage of his remarkable career. He very soon gave satisfactory evidence of his own ability and Cimabue's judgment, and produced such works as the Florentines had never seen. His was in all respects a master mind; he was a painter, sculptor, and architect; and we read of his general acquirements and character in the works of Dante, Petrarch, Boccaccio, Sacchetti, and other men of that age: his ready wit and geniality of disposition are illustrated by several anecdotes. On one occasion, when taking a walk with some friends, he met a herd of swine; one of these ran against Giotto and upset him. The painter jumped up again and exclaimed, "Well done! I have made many a florin out of your bristles, and yet have never offered you a single bowl of soup."

Giotto showed his humour even as a boy. The story of the pupil painting a fly on the face of a picture in the master's absence, and the subsequent attempt of the master to brush it off, is first told of Giotto and Cimabue.

4. To express in the fewest words the service of Giotto to art, it is this—he superseded the authority of tradition by a direct study of nature. He displayed the same independence and spirit of selection also in his ornamental work, of which the church of San Francesco at Assisi, and the Campanile or Bell-Tower of the cathedral of Florence afford good examples.

As one special result of his improvements in the art, good individual portraits were possible; and only very lately, in 1840-41, his portraits of Dante and others, in a picture of Paradise, painted in the chapel of the palace of the Podesta at Florence were, with many other fragments, recovered from the coat of whitewash in which they had been buried for centuries; these works were executed before 1300.

5. His earliest works executed in the Abbey of

Florence have perished, and the altar-piece formerly there is lost; four chapels also, which he painted in the church of Santa Croce, probably about 1296–7, before his visit to Rome, have been whitewashed: in one, the Peruzzi chapel, some works have been recovered; and it is intended to restore the others if possible. Vasari attributes also to Giotto the great picture of the "Last Supper," in the refectory of Santa Croce, a fresco, and a noble work for its period; but this is now assigned to his scholar, Taddeo Gaddi. A coronation of the Virgin by Giotto, is still preserved in one of these chapels; it is inscribed, *Opus Magistri Jocti.*

It was for the sacristy of Santa Croce that the twenty-six small pictures of the Life of Christ, and of the history of St. Francis were painted; twelve of the Life of Christ, and ten from that of St. Francis, are now in the Academy of the Arts at Florence. There is also still a large Crucifixion, painted by Giotto, in the church of Santa Maria Novella.

Giotto executed some works also in the chapel of John the Baptist, in the church of Santa Maria del Carmine; these were destroyed by fire in 1771, and Thomas Patch published in the following year prints and tracings from some portions preserved: two of these portions—three women and the infant Baptist, and the daughter of Herodias with the head of the Baptist —are in the Institution at Liverpool; a third portion, with half-figures of Saints Paul and John, is in the collection of Mr. Samuel Rogers.

6. All the above works were executed, it is supposed, while Giotto was still very young, in *tempera* or distemper, that is, with colours mixed with gum, size, egg, or fig-sap. Pure fresco-painting was not commonly practised till the latter half of the fourteenth century, and Giotto himself has the credit of its introduction. Oil-painting, as at present in use, was not discovered by the Van Eycks until upwards of a century later (1410), and was not practised by the Italians till after the middle of the fifteenth century. This last method was

introduced into Italy by Antonello of Messina, who had learnt it at Bruges of the third brother, and only surviving Van Eyck, Lambert, about 1443-5.

7. In about 1300, or a little later, when Giotto was only twenty-five years of age, assuming 1276 to be the correct year of his birth, he was invited to Assisi. To complete, says Vasari, some work left unfinished by his master Cimabue; but this is very doubtful, for Cimabue was still living in 1302. On his journey to Assisi, Giotto delayed a short time at Arezzo, and there are still in the parochial church of that place pictures of St. Francis and Dominick by him; the stoning of St. Stephen, painted in the old cathedral, perished in 1561.

Several pictures from the Life of St. Francis, in the upper and lower churches of Assisi, are attributed to Giotto; but it is impossible to fix their time, which may, however, probably have been between 1300 and 1306. Giotto appears certainly before this time to have visited Rome, where he made for Boniface VIII. the celebrated mosaic of the Disciples in the Storm, known as the "Navicella of Giotto," and now in the vestibule of St. Peter's. Baldinucci shows from a document that this mosaic was executed by order of the nephew of Boniface, in 1298, at the then enormous cost of two thousand two hundred and twenty florins—so large a sum that there is probably an error in the figures. Giotto was also in Rome probably at the Jubilee, in 1300, employed in painting for Boniface.

Some accounts make him to have executed some frescoes, rather wall-paintings, in the Campo Santo at Pisa, even before his visit to Rome; but of this there is no evidence, and the paintings from the Old Testament, illustrating the story of Job, long attributed to Giotto, have been shown to have been executed after his death. A St. Francis, by Giotto, formerly in the church of San Francesco at Pisa, is now in the Louvre at Paris. Giotto executed also many works at Rimini, Ravenna, Pistoja, Lucca, Milan, and Naples, but very little remains of these works.

8. Padua is now the richest in the genuine works of Giotto; there, in the Scrovegni chapel, in the church of the Madonna dell' Arena, is an extensive series of works executed after 1306, and probably directly after some of the works at Assisi; the greater portion are well preserved, and Giotto here appears as a great painter.

This chapel was built by Enrico di Scrovegno, in 1303, and Giotto was already engaged in its decoration in 1306: Dante, then in exile, visited him while at work in that year, and it is possible that Giotto may have commenced it the year previous. The intimacy and friendship of Giotto with Dante were probably here confirmed, as the painter was too young to have been the companion of the poet when in Florence before his exile. Dante particularly distinguishes Giotto in his *Purgatory*:—

> "Formerly Cimabue thought in Painting
> To hold the field; now the voice is Giotto's
> And the fame of the other is obscured."—xi. 32.

9. After the completion of this great work, which comprises about fifty subjects from the life of the Virgin and the history of Christ's passion, Giotto went to Avignon, when he took a present of a bronze crucifix to Pope Clement V., from Andrea Pisano; he returned to Florence in 1316.

It is quite possible that some of the important works of Giotto, supposed to have been painted in the earlier part of his career, as some of the works of Santa Croce, or even of Assisi and other distant towns, were really executed after his return from Avignon, where he also painted several works, of which there are some slight remains. He appears to have been now also much engrossed by architecture and sculpture. The Campanile of Florence belongs to this period, as well as some monumental tombs; and if the report of Vasari was true, that the first bronze gates of the baptistery of St. John, containing twenty-eight figure subjects in Gothic or Byzantine panels, were designed by

Giotto, he would have been sufficiently occupied to account for a comparative cessation of his pictorial labours, between his return from Avignon and his visit to Naples. The model of the gates representing the life of John the Baptist, was, however, completed by Andrea Pisano in 1330, and there is no mention of Giotto on the inscription. The Campanile was completed by Taddeo Gaddi, after Giotto's death.

10. In 1322 he visited Lucca, and in 1327, we find him at Naples, where he had been invited by King Robert, and he there painted a chapel in the Castell' Nuovo: this chapel has been long since destroyed. It is from an error of Vasari's, into which he was led by Lorenzo Ghiberti, that it has been commonly reported that Giotto executed the wall paintings, representing the seven sacraments, in the little church of the Incoronata at Naples, for this church was built only in the year 1352, and the picture there painted, representing the sacrament of matrimony, in which the actual marriage of Ludovico di Taranto with the queen Giovanna is commemorated, did not take place till 1347, eleven years after the death of Giotto. This great painter died at Florence in 1336, and was buried with great pomp in the cathedral of Florence.

11. The name of Giotto is great, and deservedly so as marking the era of a new epoch in art. It is possible that, as an innovator and originator, he may deserve even the whole credit of the great revolution in painting of the fourteenth century; but if we test his works by an absolute comparison with the more complete masterpieces of later times, he is at best a rude beginner; a pioneer who indicated the right path, but made very few steps in it himself. His design, or the general character of his form, is extremely hard and what may be termed Gothic, abounding in conspicuous lines and angles, and he paid little attention to either perspective, optical precision of lines and position of bodies, or chiaroscuro, *i. e.*, the treatment of light and shade as an art. composition, however, he was natural, if not dramatic.

His great excellence was in painting a head: his old men especially are frequently grand; he evidently studied the head, and he also studied common things. The praises of Dante and Petrarch have secured him a name with posterity, which he could scarcely have acquired otherwise; and it is through this distinction, doubtless, that earlier as well as later works have been indiscriminately awarded to him.

12. Cimabue was called the father of modern painting, but as there was not a very great prestige attached to his name it was not so difficult for modern research to establish the fact that there were not only Italian painters, but as good painters at least as himself, who preceded him; still, within a century, common repute attributed to Cimabue all earlier works that were not accredited to Giotto, to whom, without the least discrimination, all the best works, even of the fourteenth century, were given; and, indeed, almost every able painter, who executed any work in any part of Italy as late as the close of the fourteenth century, was at once assumed to have been the scholar of Giotto. Thus it is that many gifted artists have been deprived of their honours, and the name of the painter of the frescoes of the Incoronata at Naples is altogether unknown: he may certainly have been one of the scholars of Giotto, or at least one who profited by his example. Taddeo Gaddi lived with Giotto twenty-four years, and doubtless greatly aided him in his works while living, besides performing the important service of completing his designs after his death; a service which was so rare in the middle ages, that it was to be secured only by strong personal attachment.

13. In decorative art, which displays exactly the same new vigour discoverable in the fine art of the period, Giotto has the credit of some of the finest works of his period. The Renaissance, or Revival, comprised both art and letters—a more material, scientific, and useful tendency was exhibited in all efforts of the time. The great poems of Dante, the stories of Boccaccio and

Sacchetti, are results of the same energy and independence of mind, which developed the dramatic series of works of Giotto and his school; and in the ornamental decorations, there was a similar freedom from the old Byzantine traditions. Though nothing particularly new is displayed in the ornamental designs of the commencement of the fourteenth century, the omission of a great mass of old traditionary matter and symbolism, gave a new character to the general effect of what remained. While in Venice the Byzantine fixed types were prevalent, and even prominent, in the decorations of St. Mark's, in the south the influence of the Saracens in Sicily, under its Norman kings, had developed a taste for geometrical ornament, consisting chiefly of tracery or interlaced work, which was particularly well adapted for the peculiar glass tessellations or mosaics, then carried on in great perfection. But by the selection and exclusion, practised by Giotto and his school, there was established a *new style*, distinct both from the Siculo-Norman of the South, and the Byzantine of the North, which constituted the first individual style of the Renaissance, and from its mean time, about 1300, it is known as the Trecento. This is the peculiar style of Giotto, and of Italian decoration generally, in the North of Italy, and consists chiefly of ordinary conventional Byzantine foliage and scroll-work mixed up with interlacings or tracery, with an occasional natural treatment of the leaves. Such is the character of the work in San Francesco at Assisi attributed to Giotto; and it is the general character of the decoration of all the principal churches of the time. If the omission of the Christian symbolism, the figures of the evangelists, and other religious forms, can be considered as a secularizing of ornament, there was at least no neglect of religion, for the religious elements of church decoration, instead of being mere ordinary decorative accessories, became principal objects and subjects, to which the whole system of ornamental decoration was purely accessary.

14. There is a saying "rounder than the O of Giotto:"

this has relation to a mechanical feat performed by Giotto before he went to Rome, and, if true, may be one result of his decorative skill. Boniface VIII., wishing to decorate St. Peter's, sent an envoy to Florence and Sienna, for artists, of whom he required specimens. Giotto's specimen was a circle drawn without the aid of compasses, with a brush of red colour. This appeared more wonderful to the Pope than anything else that was sent to him, and Giotto accordingly fully justified his reputation in the estimation of the Roman court. It is a strange story; but there was in London some eighty years ago a cooper who could do the same with a piece of chalk on a board, and many a shilling he won by correctly performing the feat in the presence of those disposed to wager with him.

Though an innovator in many things, Giotto introduced no pagan elements into his decorations. Like his friend Dante, he was certainly one of the great pioneers of the modern revival of the arts and sciences, who performed the necessary preliminary labours of clearing away the accumulated obstructions that the indolence and ignorance of ages had so long suffered to impede all human progress.

LESSON II.

HOW TO LOOK AT A PICTURE.

1. Various are the pleasures, and very different the degrees of instruction, to be derived from the contemplation of a work of art: there are the uneducated and the educated eyes, which, though regarding the same objects, may see different things. Some eyes observe closely, some superficially; but the observation of all greatly depends in its quality, on the amount of education or experience possessed, which must also regulate the degree of instruction or pleasure derived from a

work of art, and determine the quality of the judgment of the observer.

"A painter to judge a picture," is an old saying; yet it is true in a very limited sense, no further indeed than the experience of the painter has specially qualified him; and that is in the technical process by which the picture was produced. It is only one of the corroborations of the assertion above that the judgment of the picture must be qualified by the experience of the observer. That an intelligent painter may bring other general qualifications to the task besides his special technical experience is a matter of course: his very profession has given him a power of observation, more exercised in the examination of particulars, than is usual with the mass of ordinary observers; but the special province of the painter, as a judge of a picture, is simply whether it be well painted or not, and this even wholly without any guarantee for the accuracy of the representation.

2. Waiving for the present all consideration of what may be termed a professional judgment, which, from its bias to criticise means, rather than results, is precluded in a great degree from the genuine enjoyment of a work of art, for its own sake as such we will endeavour to show how many ways there are of receiving pleasure and instruction from a picture.

3. In the first place, it is necessary to guard against the too vulgar notion that we are to look upon the picture of an object or scene as a reality or as an illusion. Illusion, or the perfection of imitation, or even the approximation to perfection in accordance with our own limited knowledge of things, is certainly the simplest and commonest source of pleasure derived from a picture; but the power of imitation is also the lowest attribute of painting, though, in itself, illusion can result only from an accurate observation and a perfect mastery over the mechanical means.

4. In walking through a picture-gallery, different pictures will be found to arrest the attention of different

visitors, in probably a like degree; but certain works will attract many admirers, while some attract only very few. Dutch pictures, as a "Lemon on a Plate," are invariably more popular with the people than Italian in this country; while in Italy they would meet with only a partial admiration from the Italians, compared with the devotion they show to the more genial and characteristic works of their own painters, as "a Crucifixion:" the former is a natural and the latter an acquired taste, or the result of education, and both arise independently of any art-cultivation. The English mind is pleased by the imitation of familiar objects, while the Italian mind is attracted by the mere religious subject of the picture, without giving a thought to the art that produced it. We have here prominently displayed two distinct provinces of art-operation—the *means* alone acting in the first case, and the *end* alone in the second; one admires the imitation, the other is impressed by a superstition: the picture is, however, in neither case thoroughly enjoyed, though the object of the artist may have been attained in both instances.

5. There is much more than this in painting: it is right to admire a picture as a work of fine art, but it is the nature and treatment of the subject that in most cases are the real source of pleasure and instruction to be derived from it; and this power of the picture increases in proportion to our own knowledge and cultivation. A genuine modesty will withhold a judgment on a picture, when the presumption of ignorance will at once pronounce an opinion; and the promptness and facility with which many persons habitually decide on works of art, is very much more nearly allied to the readiness of mere presumption than the result of a profound knowledge.

6. As every picture is submitted to many judgments, a false judgment must be an infinitely commoner thing than even a bad picture. The simplest and most unsophisticated of all judgments is—"Oh, how real!" This is the first stage of art-criticism, its infancy; and

there are doubtless many grown-up people who are always infants in matters of art; they look only at the imitation. Such a judgment, or, what is the same, such a limited sphere of admiration, restricts their powers of appreciation and enjoyment to familiar objects only; and the cultivation of this narrow view of art will, from habit, render works of art, as a rule, generally incapable of conveying either instruction or pleasure to such people, beyond the trite, and when familiar, questionable pleasure of *illusion*, in the representation of common objects: if the object is uncommon and unknown, the mere pleasure of illusion is wanting, and the picture is regarded with perfect indifference, and so much art is thrown away. This is only one deplorable result from not knowing how to look at a picture; yet the being debarred the aid of instruction and pleasure from so noble an art may appear an extreme estimation of the consequences of an idle, or merely simple habit of observation. This is, however, a true view of the subject: people of this habit of observation learn nothing from picture galleries and take no pleasure in them.

7. Where imitation is the criterion by which a picture is judged, the sphere of the artist is limited to the sphere of experience of the observer; what is familiar is understood and appreciated, but what is not familiar is regarded with indifference, and the mind is closed against the means of instruction afforded by pictures of unfamiliar objects. We may illustrate this position, by the example of two portraits, one of an intimate friend, the other of a stranger; the former may excite raptures, while the latter will not even attract attention: the representation of the familiar object only is appreciated. This is clearly a bad habit of observation.

8. The execution of a picture may be assumed to comprise the whole treatment of a subject; the mere manipulation of light and shade and colour is only an inferior portion of it, the more essential truth and sentiment being always expressed in the composition,

and expression of the figures. A basket of vegetables might be a perfect picture, yet it would want every quality of a great work of art—original thought, composition, expression, all human emotion and sentiment: these are the great bearings of a picture, that every true connoisseur allows his mind to dwell upon: he can assume a work of art to be a natural representation, without requiring that the actual imitation shall be illusive: he can enter into its emotions and the motives of the painter, and at the same time admire the picture as a work of art. He has no wish, even for a moment, to imagine a reality.

We may admire the object, and the subject represented, the mind that conceived, and the hand that executed the picture; and we may also naturally encourage every reflection that the original itself might suggest: and this power of supposing or meditating on the reality is that which is to be cultivated, as the first stage for deriving either pleasure or instruction from a work of art; and it is so different a thing from admiring illusion, that it supposes for the moment all notion of art to be dormant: this is a condition absolutely compelled by great works of art.

9. What is called the spirit of criticism itself is generally bad; it is only another name for fault-finding: in most cases dissatisfaction arises much more from imperfect judgment than from imperfect execution. We are apt to imagine ourselves familiar with scenes and objects, when we really possess only a most superficial apprehension of them. We should invariably doubt our own judgment in a matter on which we are only casually informed; while the fact of its representation by the painter presents some evidence that he at least has given it a special study, in order to represent it. Of course as long as painters are imperfectly educated, anachronisms and other errors will occur, and at one time, when painters were not nearly as well educated as they are now, singular mistakes were made: there is a picture in the gallery at Munich by the old German

painter Altdorfer, of "Alexander's battle of Arbela," in which modern artillery is represented. So little is generally known of costume, that errors of that kind have been habitually overlooked as a matter of course, though these errors will gradually disappear as the education of the artist is improved. As a minor error, may be mentioned the introduction of plants and foliage into scenes, where naturally such plants and foliage could not exist. These are all, however, minor drawbacks, not very common, or at least, not very prominent, and are no excuse for the spirit of fault-finding, which is by far too universal in the examination of works of art.

10. There are further many mischievous habits of observation, which are not only injurious to the painter, but debar the observer from much of the advantage that he might derive from the opportunity of viewing a picture. Some are too general, and some are too special in their observation; some, if they do not at once observe a certain favourite general effect, a certain tone, or harmony of colour, or facility of touch, draw away from a picture and really do not look at it at all; others look minutely at parts, and altogether lose both the general effect of it as a work of art, and the moral value of the subject. Some waste their time in attempting to discover *hands*. These observers pass through a whole picture gallery, without having done anything beyond making many unsuccessful attempts at discovering the painter by the handling of his work; and would derive much more gratification from some few successful results of their diagnosis, than from all the subject-matter and art-skill combined, illustrated by a whole gallery of pictures. These too are bad habits of observation; but they are more the vices of the expert than the simple: and vices of this kind are very various; some quarrel with a high point of sight, some with a low, &c. All these habits, perhaps, come under the class of prejudices, and are, to use an art term, *subjective*, instead of *objective* methods of looking at picture; that is, testing a work by our own preconceived

notions of what it ought to be, rather than accepting it as an additional new experience, or object of contemplation for the mind in all its bearings; in relation to its subject, and to its mode of treatment. We should never overlook the motive that must have decided with the painter, both the selection and the special mode of treatment of his subject.

11. To view then a picture with the utmost advantage to the painter and to ourselves, we must first divest the mind of all prejudice and predilection; then endeavour to master the subject, and, if possible, realize it in our minds, which it is only difficult to do when a picture is decidedly mannered and false: we may then allow incidents in detail to tell their own story; satisfaction will soon grow into approval, pleasure and instruction will be evolved; and admiration for the art and artist will be the natural result.

12. This is necessarily the natural process with many simple minds, and it is also the studied method of observation with experienced connoisseurs, whose purpose it is to enjoy and appreciate pictures. With such minds criticism is an after-process; but the very method itself is impossible with bad pictures, and with systematically mannered productions, which come into the category of subjective works; that is, where the object is represented in a light or atmosphere quite peculiar to the painter; as, for example, with Rembrandt or Turner: whose individualities, more particularly in the case of the latter, originally founded on truth, and grandly conceived, were eventually exaggerated beyond all natural possibility, and descended into an extravagant mannerism. These and other great painters have had their own peculiar methods of representing nature; but as in this method we must recognise the peculiar idiosyncrasy or individuality of the painter, so we must endeavour to enter into the same spirit, before we can fairly test the merit of his work. Nature has an infinite variety of aspects, ob-

jectively as well as subjectively; for nature's varieties assume new changes, when seen with the eyes of others: there are sunny and cloudy spots, and sunny and cloudy moments. We may prefer the sunny to the cloudy, but the cloudy are as natural as the sunny, and there are many to whom the cloudy may be more genial. The Alpine glaciers and the parched deserts are equally natural and true, yet both may be wholly beyond the limits of our experience; but even within our own experiences there are many phases that have escaped our observation; these the painter may choose especially to dwell upon, and thus stamp his works with an individuality really true and natural, but yet always liable, on superficial observation, to the imputation of mannerism. On inspecting a work of art, therefore, unless the mind endeavours to enter thoroughly into its spirit, or the object of the artist, the inspection must be superficial and imperfect. Throughout whole periods of art-history, *sentiment* was the prevailing object of attainment with the artist; the material forms were but the means of conveying the spiritual purpose of the picture. This is sufficiently illustrated by the works of Pietro Perugino and of Francia. If we regard merely the objects introduced into the pictures of these painters as such, and test them by an actual comparison with the realities, or in their dramatic relation to each other in their compositions, the result will be unsatisfactory; but not so much from the imperfection of the painter as of our own observation; we make principal, what was in the painter's mind wholly subordinate to, in his case, a much higher aim than we have allowed our minds even to contemplate. Thus it is not a superior judgment condemning an inferior work of art, but an imperfect observation attempting what is beyond its comprehension.

13. Different periods and schools have generally been characterized by distinct aims. In the fifteenth century, in Italy, or with the great *quattrocento* masters, as the Italians term them, sentiment prevailed;

in the sixteenth century, or with the great *cinquecento* masters, a combination of material beauties and perfections with the sentimental, was attempted and achieved. The fascinations, however, of these material developments of form, and colour, and composition, proved so engrossing as to absorb the painter's attention, and the higher qualities of the heart and mind were gradually neglected, and eventually overlooked in the academic schools. Later still, even the generalizing and idealizing of forms were neglected for simple executive skill, and illusion became the aim of a large class of painters: the selection and nature of an object were now immaterial, and the whole effort was bestowed on an illusive imitation. Such is a broad analysis of the various styles of the different schools, which at least show a variety of aims that a picture may display, and also that all these views must be borne in mind in the examination of a picture, if we are to observe it with the greatest advantage to the painter or to ourselves.

14. As an illustration of the application of these principles of observation to a picture, let us assume an inspection of the "Last Supper," by Leonardo Da Vinci, in the refectory of the convent of Santa Maria delle Grazie at Milan, not in its present decayed state, but in its original perfect condition at the close of the fifteenth century. The subject of the picture is not thirteen men at supper, but the sentiment supplied in the words of the Lord, "One of you will betray me," and the sudden effect of such an extraordinary announcement on the minds of the apostles. We are therefore to look for the representation of expression and the illustration of varieties of character: by such method the subject will be easily and powerfully realized, and the greatness of this celebrated work at once intelligible; but if, on the other hand, we look for illusion or good objective imitation, an illustration of Jewish customs, or the ordinary incidents of a meal, we shall be disappointed with this great work, though

justly creating an era in art. In all these minor respects this celebrated picture would bear no comparison with even very ordinary productions of modern times: all objects introduced, and the whole arrangement of the figures are accessory to the one great aim of expression. This picture illustrates, to a certain extent, the subjective treatment, and had the subordinate elements been made more prominent, means would be mistaken for ends, and its higher qualities would have wholly escaped those observers, whose minds, by experience or otherwise, had never been disciplined into the proper methods of looking at a picture. All the processes here indicated must be the habit of a good observer.

15. There are further some mechanical considerations necessary, but which are so obvious that they need scarcely be dwelt upon. While small elaborated cabinet pieces require a close inspection, large gallery pictures must be viewed from a distance: the very distance will sometimes give a finish to a picture, the absence of which, on a close inspection, will be an injury to it in the mind of the inexperienced. Some pictures, especially landscapes, require to be viewed from a particular spot, sufficiently indicated by the perspective features of the composition: the observance of this practice will often be of great advantage to a picture. The style of execution also will often decide the object of a painter, which may be otherwise difficult to discover: while the elaborate and careful execution merits a minute observation, the bold and negligent as obviously demands a more distant and general inspection; a mere pleasing ornamental general effect is only too frequently the principal aim of the painter—a result by no means surprising where technical skill is made the painter's capital qualification.—R. N. Wornum.

LESSON III.

HOW TO ENJOY A PICTURE GALLERY EVEN IF YOU ARE NO ARTIST.

BY MUIRHEAD MITCHELL.

1. MANY people—especially English people—will be surprised to learn that "Art" has a history, that books have been written upon it of most interesting character and well worth studying; that this art history is intimately connected with all history of every time, and exemplifies in considerable variety the manners, the customs, the feelings, the habits, the morals, and the religion of the different periods of the world. We are obliged to confine ourselves to painting, omitting sculpture and architecture. There are few paintings of very ancient date, with the exception of those at Pompeii, and some in the catacombs at Rome. I believe none older than the eighth century. The oldest in our National Gallery, by Taddeo Gaddi, are of about the year 1350, and it is from this period we shall commence our slight sketch.

2. The principal schools are the Florentine, the Roman, the Venetian, the Bolognese, the Ferrarese, the Parmese, the Milanese, the Neapolitan, the Flemish, German, Dutch, French, Spanish, and English. Each of these has its own distinctive characters, and its several periods, its chief painters, their scholars and imitators. The earliest artists seem to have followed the Byzantine type, and the subjects are always religious—with very imperfect drawing—very indifferent colouring: but a deep sentiment of religious feeling pervades these works; they require to be looked at with faith, with the faith of the time, the faith that inspired the artist, often an ecclesiastic or semi-ecclesiastic. It was the period of the Crusades, and they tell us much of the under-current of public thought which led to those apparently-useless parades, costly in blood and treasure, effecting little for religion. but doing much for civilization through the interchange

of thought created. Giunta Pisano, Cimabue, and Giotto are the earliest artists of the Florentine school, and Taddeo Gaddi was scholar of the last. His work in the National Gallery is a collection of Saints: they stand together; they have no apparent connexion with each other; they gaze into the vast infinite; they have been martyrs for the cause; and their exquisite enjoyment consists in the contemplation of His glories for whom they suffered. You will observe each carries his appropriate emblem—St. Stephen has a stone, St. Peter a sword, St. Catherine a wheel; others palm branches; virgin saints lilies.

3. Art began with feeling; men poured out their souls as the early poets might have done words full of depth and signification; terrible or beautiful in their mystery, in their powerlessness to explain adequately their meaning. They were the utterings of the infant Hercules, with language unequal to express his thoughts, who yet by sign and action conveys great and grand, and holy and potent impressions. The next period develops more strength; the idea has clothed itself with words; the powerful thought is no less powerfully expressed. Artistic beauty learns to aid intense feeling to manifest itself. You will find this in Leonardo da Vinci, Andrea del Sarto, the early periods of Raphael, of his master Perugino, of Giovanni, Bellini, of Francia. There are some of the early Flemish and German masters also who may be here classed. But there is, to my mind, always a greater coarseness of tone and feeling in Flemish art as compared with Italian. The graceful, the noble, is wanting—I may be wrong—it is matter of feeling.

4. The Francias in the National Gallery are specimens of this period of art. To feel their exquisite beauty you must go with an humble mind to view them; you must take all your best thoughts, all your holiest feelings, all your parental, all your filial love. You must wean yourself from the world without, its gaieties, its pleasures, its rivalries, its animosities, its contentions.

You may take your sorrows, and if in this way you have truly learned the motives of those pictures by this means, you will recur to them again and again; you will obtain new and pure impressions; and you will be, for a time at least, a holier and a better man, just as you would be had you read some blessed spiritual book, whose office is to lead to heaven. It is evident that pictures of this class lose their significance and feeling when placed in a gallery; their position is the oratory. The "St. Catherine" of Raphael is of this order. There is one necessary caution here—don't imagine you can attain the feeling for these pictures without knowledge. You must go again and again to study them, to pore over them. You must have the religious, the poetic sometimes in your own soul, or you will look at them in vain. When you have weaned yourself from West, you may begin to admire Raphael's early style, or Francia, or Fra Angelico. Humility is the first virtue in a poetic admirer of the arts; and don't believe that there necessarily *is* nothing in what learned men have learned to love, simply because *you can see* nothing in it. If you would enjoy the full prospect, you must climb the hill of art with labour, a labour of love. In this, as in everything that is valuable, the prize is to him that works.

5. A period now succeeds in which art attained its greatest perfection. Though the religious sentiment was not altogether abandoned, worldly ideas, but of high order, are introduced. The subjects are derived sometimes from the classics; not alone from the Scriptures, or the legends of the Church; the artistic excellence predominates; the feeling is passing away. You are attracted by exquisite drawing, by wonderful composition, by magnificent and harmonious colouring, by action of individuals and of masses, by perspective, by foreshortening, by modelling of the figure, by architectural developments, by landscape no longer conventional, by all that knowledge and science can effect. You have come out from the chapel and the

holy sanctuary, you have entered the noble palace; the sweet joys of heaven have vanished, or are shrouded in a beautiful mystic distance, and you walk with pride on splendid terraces, in glorious halls, amid gold and precious stuffs and jewels, and the excellent things of the earth; with kings and princes, and noble-dames, and grand ecclesiastics, fit denizens of such a world of highest pomp: every expression is lofty—there is no meanness there. Those people do not love you, do not hate you; you feel no humility in gazing upon them; you become one of them in thought yourself; you tread with them those marble pavements; you throw around you that glorious velvet robe; you doff your feathered cap to that admired and worth-all-admiration lady; you talk with them on matters of high moment; you feel yourself elevated by the glow of that clear bright eye, by the bend of that noble brow, so full of thought; by the high purpose of the glorious company around you; you settle the affairs of nations; you tread a proud, a noble, a glorious creature yourself; you feel no condescension; you are simply proud, honourably proud; and when at last you are recalled by the necessities of time, and the closing of the Gallery, to the world you really live in, you thank God for the dream which has elevated you; you think better of human nature, and you drop your dole of charity and some kind words of pity to the poor beggar man, boy, or woman, whom you had spurned as you went up the steps of the façade; you recognize them as brethren, for they have souls.

6. Not only, however, are the pictures themselves and their subjects objects of your attention, or capable of enhancing your delights; the history of each individual artist calls up its recollections: you read not the poem alone, but the poet; and you find the impress of the man, his youth, his middle age, his slow progressive decay in his very works. Not many lived—I mean of the greatest ones—to meet this latest stage, and some even of those that did die, died not of decay,

died full of years and honour; Nature wore out their bodies, but their souls were ever fresh. The plague killed Titian at ninety-nine; I know not what disease carried off Michel-angelo at eighty-nine.

7. Each picture also has its history—a beginning, a middle, an end. We read of one who never sat to paint till he had steeped his inmost soul in prayer; of another who, an Algerine slave, purchased his redemption by the portrait of his master; of one picture painted in rivalry, perhaps a jealous, perhaps a generous, rivalry; of another, at which an Emperor stooped to lift the painter's fallen brush; of another, a portrait for a king to look at, and make the original his bride—oh! and when he saw the lady he felt the painter's art was false: of one painter who sat alone midst war's alarms, and the clang of trumpets, and the clash of swords, and painted on and on; and the rude soldiers forced his studio door, and, warm with recent blood and hope of present spoil, stayed on its threshold, gazed on the ideal art, and sheathed the sword, and closed the door, and set a watch to guard that no unholy foot intrude to mar the painter's thought, or breathe a stain on his created beauty. Other pictures, too, tell us of the painter's life. This was sold when he was poor, unknown, an early work—his first that raised him up to fame—that was an order when the world had recognised his value. This was painted to show his love to one that had befriended him in early youth; *that* for some Lorenzo the Magnificent; *this*, again, as a cutting sarcasm on some secret or open foe. Here are his wife and children, there his mistress. Here his dear acquaintance from whom he gained his inspiration or added to his lore. There his favoured models; and then the history of those models, the loves they had, the fate they underwent: those children, their future, how seldom prosperous or splendid—and how they told upon the artist's life. You see that gorgeous lady, observe her splendid full Venetian form; amid thousands you could not fail to point her out. Mark her eye; mark her mouth. You may believe that she had power—

that she could sway, as the tempest-wind a willow wand, the poor artist's brain—his heart. She was his muse, his inspiration—his life—his love—his all. One day she left him desolate. I know not whether wealth commanded more than art that lady's love; I only know she left the artist, and the world became to him a blank. I wrote beneath an engraving of her picture, How rightly it is called "La Vanité." Let us at least weep over if we must also condemn the failings of genius.

8. There is pleasure also in tracing the history of a picture itself after it has left the studio-birthplace. It is, perhaps, four hundred years old. It may have been fetched in solemn pomp, by an assembled people, to the sound of the harp, sackbut, psaltery, and all kinds of music, and placed with all the splendour of religious pomp upon the high altar of a church, delighting in outward ornaments of worship. Thousands of votaries for ages may have knelt to gaze on it, some with holy awe, some with superstitious reverence. The virgin bride hath pledged her vows; the lonely monk at midnight knelt in prayer before it; holy solemnities without number it has witnessed; the very droppings of the sacred lights may be traced upon its foothold; and rude revolution has rushed in, and the holy vessels of the altar have been stolen, and profane money-changers have purchased the object ages have venerated, and it is torn from its high resting-place, and a cellar conceals it for years; and it is transported to another clime, and first one and then another connoisseur has purchased and sold it; and at last it hangs there, there where it now hangs; and the every-day world—pass it unheeded by; till all at once it becomes, for some one has found out its value, again a wonder and a gazement.

9. There are others, too, painted for king's chambers; that have heard tyrants rage; seen noble men led out to execution; listened to plotting traitors; smiled still serene as now, though the fond mother in vain hath pleaded for her husband's life. Some, too, that have seen the mournful countenance of anxious kings, mayhap beheld

them as they walked to execution, or rushed to exile. What fearful tales they might have told! Some, too, show on themselves the marks of such events. From one some friendly hand cut out a king's head to save it from destruction. Another marks a momentary fit of modesty or prudery in the most licentious Ducal of his age. Both have been restored.

Oh! it is strange to trace these pictures thus from pillar to post. Now a king's, and now a peasant's; now in a monarch's best chamber and most honoured place; now on the field of battle, hurried off in an invading general's baggage, seized again by the opponent's army, resting peacefully in a hero's palace, smiling on commemorative feasts of Waterloo, and then admired by all true artists on the walls of some gallery of public exhibition.

10. Having thus considered the externals of a picture, the history of its artist, the character of its representations, we come to consider what is in the picture itself, what to observe in it. And first, we must ascertain what is its class. Is it historical—a portrait—a landscape—a Scripture piece—a conversation piece—an animal piece or, mere *genre*, that is, ordinary life—and in each of these there are minor details to be looked at, which we shall proceed to point out.

To understand a picture, and appreciate it fully, we must ask ourselves what school it belongs to—what period of that school—what master painted it—what style of that master it is in—what is the subject of the picture—how that subject is treated? We will observe on what surface it is painted, the size, the texture —whether the style is bold or finished—the proper distance at which to stand to view it with the right effect. We must then ascertain its motives; that is, the idea that was working in the artist's mind when painting it, and it would be well to know the traditions of the subject, if religious, or from the antique. Are these motives natural or ideal? We shall then ascertain the condition of the picture; whether it is as it came from the artist's hand—whether darkened by time—whether the colour has flown or improved—whether it has been cleaned and repaired—and how far this may have altered the character. We shall see whether anything has been added to it or painted out. We shall inquire, too, whether it be a copy or a duplicate; or the work of a pupil of the master whose name it bears, with or without touches by the master himself—whether one designed it and another drew it, and a third coloured it—whether it is a powerful or weak picture of the master—whether really by the master to whom attributed? We shall ask ourselves how it was painted—whether on a dark ground or a light one—does the ground come through and show itself, or is at all covered with the impaste—is the impaste thick or thin? Is the handling hard and sharp, or soft and smooth—what is the vehicle used, and how is it used—with what is it varnished—what parts are varnished, what left clean?

What is the effect of the picture?—is it cold or warm—what period it represents—sunrise—midday—crepuscule night—storm—clear and bright—moonlight—lamplight—æthereal? Are the effects natural or extraordinary, real or false?

Is the picture damaged—is there a chill on any part of it?

How is it hung—high or low—the colour of the wall—the effect of ornaments or other pictures near it—the position of the windows—the size of the room or gallery, and its form?

The day the picture looks best by. One warm and sunny or grey—in a full light, or rather shaded—in the morning or in the evening?

In what does its excellence consist—in the drawing—composition—colour—local colour? What are the accessories, and the reason of their introduction? What are the defects—how might they have been remedied—speculate on alterations of colour or form?

What extraneous circumstances does the picture suggest of manners, customs, thoughts, ideas, of the times in which produced—or of the phases of nature—or of the mental powers of the artist? Its effects on the soul of the beholder—on the informed or on the ignorant? Its power to produce excitement in the masses or the individual.

11. We go on to point out some few things to be observed in religious pictures :—First the subject, then the sentiment—the expression of the time when painted—the thoughts or ideas of the century—the impression it produces on the mind. The country and school of the painter—his name and character—and the period of his life when painted.

Is it really scriptural or merely legendary—the different legends of the subject? Is it treated with attempt to develop the antique dress, or in the dress of the artist's time, or conventionally and artistically; whether it is a religious picture, or only a picture with a religious name, or semi-religious? Is it merely decorative, or does it convey feeling or instruction? Is it treated naturally or spiritually? Is it rightly named? Does it please at once, or only after a time? What class of mind is it suited to? Is it gratifying only to the artist, or to the educated, or to the general mass? Does it ennoble or debase its subject? You will observe the composition and colouring, the character of the heads; the garments and drapery, the background, the anatomy, the modelling, the costume, the fleshtints, warm or cool, the unity of the picture. Whether it tells its tale; whether it tells in the background other matters connected with the subject. Is the action momentary or continued? Is the principal figure interesting or not? The expression of the grouping, and of the heads, particularly of the Virgin and Child. Are the accessories appropriate—are they too prominent?—why introduced? to tell the tale, or make up the picture?

Is it graceful—horrible—exaggerated—in action, or repose—why harmonious—why not so? Is gold used—to what extent—on backgrounds, or on garments—any other means of producing effect, such as raised work on panels or plaster?

Observe the ornaments—cups—vessels—tables—jewels—costume—material of clothing—the architecture—workmen's tools—animals. &c.

12. I have written enough to show that there is much to be studied in a picture gallery, and much to be learned before a man can enter fully into the pleature it is capable of affording. He must vie with the ancient orator. He must know everything, history—poetry—science—art—anecdote—anatomy—expression—love—nature—and above all, have a heart that can feel. It is not a day that produces this knowledge—but if we begin at once we may go on increasing our knowledge year by year, and every year will add increased joy to us when reading the thoughts with which the room is hung. It is labour—all that is good is labour—but it is labour that fully pays. To the very oldest period of life it adds still its charm.—MUIRHEAD MITCHELL.

English Literature.

BY GEORGE CRAIK.

LESSON I.

ENGLISH FORMS OF LITERATURE.

1. WHAT is properly called the Literature of a language is only a small portion of all that has been written in it. It by no means includes either all the positive information and knowledge or all the speculation that is to be found in the language. There are thousands and tens of thousands of English books of the greatest utility and importance that make no part of English Literature. It is not the amount of information contained in a book, or in any piece of writing, that gives it its purely literary character and value, but something of a different kind altogether. It is not the

matter or substance of the composition, but its manner or form.

2. If it were proposed to take a survey of all that is to be found written in a language, the most natural and convenient mode of proceeding might be to distribute the statement according to subjects. Thus, in a complete inventory of what has been written in English, Thomson's Seasons might be placed among works on Agriculture, and Young's Night Thoughts under the head of Religion, and Shakespeare's historical plays along with the Histories of Rapin and Hume. But such a classification is inadmissible in a view of English literature. There Shakespeare's dramas and Thomson's and Young's poems must be regarded as belonging to the same kind of writing, though to different departments of it; such works as Hume's History will come under another general head; and Rapin's History and a crowd of others will not be recognized at all.

3. The Literature of a people is a thing of the same kind with their music, their painting, their sculpture, and their architecture. All are alike products of that peculiar kind of working which is specially denominated the artistic, and of which the different modes of manifestation are distinguished by the name of the Fine Arts. Now the constituent element, or what we may call the soul, of every production of the fine arts is its form or shape. Of course, form is also a quality of such productions as are purely useful and mechanical; but in these it is either of no importance whatever, or of consequence only for the sake of something else which it involves, or to which it is essential or subservient. In itself it is nothing. In an artistic production, on the contrary, the form is either the principal thing, or it is all in all; it is valued for itself; and it produces its effect by its own direct and immediate action upon the mind or the senses. Form here, and here only, addresses itself to a particular part of

our constitution, our sense of the Beautiful, which has been given to us for its appreciation; and through that capacity it affects us, not after any process of calculation or inference, but at once, with admiration and delight.

4. What is to be regarded as the literature of a language, then, is only so much of all that has been written in it as has more or less of this character. It follows that nothing which admits either of being perfectly translated, or of being otherwise transformed or recast without injury, can be held to make any part of the national literature. All books of mere information are in that predicament. In them the particular form is nothing in itself, but is valued by us only, if at all, for certain conveniences which it may bring along with it. Only let us retain these results, the same lucidity of exposition, and the same commodious arrangement for consultation or reference, with some other form, and it makes no difference to us. We have lost nothing. Works of this description, therefore, are not of the nature of eternal and unchangeable monuments, but are rather to be accounted as belonging to the class of those articles of various kinds which must be continually produced for constant use and consumption. They may be compared to the ordinary dwelling-houses of a country, in the construction of which convenience is the first thing or the one thing that is regarded, and which, having been designed for only a temporary purpose, are altered and renewed, or swept away altogether, without hesitation or regret, on any change of circumstances or even of fashion; the national architecture does not consist in these, but in those structures of an essentially ornamental character, many of them being purely ornamental, which are created to last, if possible, for ever, and which no one ever dreams of improving or in any way remodelling. So a national literature consists, not in works which, however serviceable for the moment, are, from their nature, liable, with the advance of know-

ledge, to be superseded, and to have their places supplied with advantage by others, but in such as are not to be thus either supplanted or mended.

5. There is only one respect in which it may seem that a literary composition of an artistic character can be touched by time. The language in which it is written may become antiquated. But, after all, this is no irremediable evil. The existence of every kind of human production is dependent upon the durability of the material of which it is constructed. But almost any other material is more subject to decay or destruction than language. The happiest and most elaborate creation of the architect or of the sculptor is doomed to waste with years, or may in a moment be shivered and laid in ruins. The greatest number, and the greatest, of such works have thus perished. But a literary composition is beyond the reach of such destruction as this. Even if there were no other means but by the living memory, its perfect preservation would be easy, so long as there was any general desire to preserve it: with writing, and still more with printing, whatever has once been put into words may with very little trouble be almost certainly secured against the chance of being lost. And if, sometimes, while the words are preserved, the ready apprehension of their meaning, which was once universal, has to a great extent been lost, it is in general easily recovered. At this day, it is possible for an Englishman to acquire the power of enjoying the Latin poetry of Virgil or Horace, written eighteen centuries ago, or the Greek poetry of Homer, whose date is perhaps nearly a thousand years more remote; the labour is comparatively nothing which would enable any one to read with ease and pleasure whatever there may be that is worth reading, written in any antique form of his own language.

6. Every modern language has arisen and been formed out of some previously existing language or languages. Thus, the present Italian, Spanish, and French lan-

guages have all grown principally out of the old Latin; they are Latin transformed or corrupted, with a certain intermixture in each case of some other tongue, Celtic, or Gothic, or Arabic. In this way it might be said that Latin itself, for instance, is only an older Italian, and that the works of Virgil and of Livy are really written in the same language with those of Tasso and Boccaccio.

7. Nevertheless, the fact is, with regard to most or all the languages now spoken in Europe, that, even while their derivation from other older forms of speech may be clear and undeniable, they are yet separated by a complete break from those previously existing forms. Thus, the present Italian and French languages, for example, are really both of them as distinct from the Latin, as they are from each other. Their connexion is not that of continuity, but only of relationship. The Italian and French may be said to be sister tongues, and the Latin to be the mother of them both.

8. Sometimes again, however, it happens that a language gradually undergoes a transformation which may be rather compared to what takes place in the passage of the individual through the successive stages of his existence. In this case, it cannot be said that a new language has come into being; the later form is only the development, or it may be the decay, of the former. We have here no separate individualities, no such distinction as that of mother and daughter, of parent and child; if there be any relationship to be designated by terms of this kind, it is only in the sense in which it has been said that the boy is father of the man, or in which any one in the latest stage of life might be figuratively represented as the son of his own middle age or the grandson of his own youth.

9. The history of our own tongue exemplifies both the kinds of change that have been described. Our present English is mainly the offspring or product of an intermixture of French with the language spoken in the country before its conquest by the Normans in the

eleventh century, commonly called by modern philologists the Anglo-Saxon. The latter, indeed, was in its own day called English, as well as the tongue that we now speak and write; English, in fact has been the proper appellation both of the language and of the people of South Britain ever since the settlement there of the Angles and Saxons in the fifth and sixth centuries, immediately after the breaking up of the dominion of the Romans. Whether it was that the Angles formed the more important division of the new occupants, or that literature sprung up among them sooner than among the Saxons, it was their name that the country now assumed; *England* is only a worn down or smoothened form of *Engla-land*, that is, the land of the Angles. And the language was anciently as seldom called either Saxon or Anglo-Saxon as the people were called Saxons or the country Saxony. It was universally known as English, that is, the language of the Angles, being the same name by which our present language is known all over the world. Nevertheless the English of the period preceding the Norman conquest must be regarded as quite a distinct language from our present English. It is at least as distinct as the ancient Latin is from the modern Italian or the French. Works written in that former English, therefore, or what has come to be usually denominated Anglo-Saxon, clearly make no part of what is now to be understood by English literature.

10. But even if we confine ourselves to our present English, we shall find that it has undergone great changes since it first acquired the general character which may be said to distinguish and divide it from the Anglo-Saxon, or English that was in use before the Norman conquest. Its progress may be most philosophically distributed into three portions or stages. First, there is a space of time in which it existed with little or no intermixture of French: this may be held to extend down to about the middle of the thirteenth century, or over the first two centuries after the Conquest, although

for our present purpose it is unnecessary to enter into any investigation as to the date at which it may be most properly considered that Anglo-Saxon ends and English begins. Secondly, there is the period during which our present English, composed of Anglo-Saxon, or old English, and French, was in course of formation; this may be held to extend from the middle of the thirteenth century to the middle of the sixteenth. Lastly, there is the period since the middle of the sixteenth century, throughout which the language may be said to have been the same in all material respects that it still is.

LESSON II.

EARLY PERIOD.

1. VARIOUS compositions have come down to us even from the earliest of the three periods, and they possess great importance from the evidence which they supply of the condition and progress of the language in its commencing stage, while some of them besides are in the highest degree interesting as memorials of the state of the national civilization generally at that remote date, and, if not for any historical information which they may contain, yet for the traces which they preserve of manners and customs and ways of thinking which are now passed away and forgotten. Of the longer works belonging to this period the most important that we possess is the verse Chronicle of early British and Saxon history which bears the name of Layamon, and which appears to have been written about the end of the twelfth century. It has now been printed in full. But neither in this performance, nor in any of the shorter pieces that have descended to us from the first two centuries after the Conquest, is there any pervading spirit of artistic conception or execution. They are interesting not as productions of art at all, but only as curiosities. It was not merely the language that was still immature and unfashioned at the date when they

were composed; everything else was in the same state of rudeness and barbarism; the feeling of true taste in writing had hardly yet awakened in the English mind. Nothing, accordingly, that was then produced, lives in the national heart or memory, or can be regarded as making any part of our existing literature.

2. The produce that remains of the next stage in the history of the language, or of the era extending from about the middle of the thirteenth to the middle of the sixteenth century, is, as may be supposed, much more abundant; and, upon the whole, it is considerably superior to that of the preceding period in quality as well as in quantity. The collection of scriptural histories in verse called the Ormulum, and the metrical Chronicles of Robert of Gloucester and Robert de Brunne, with the religious poetry of the latter, all of which compositions may be assigned to the first of the present three centuries, or to the space between 1250 and 1350, may not show much of an advance upon Layamon in any other respect than in the approach of the language somewhat nearer to the forms now in use; but in other compositions, belonging to a somewhat later date, such especially as Langland's Visions of Pierce Ploughman and the poems of Laurence Minot, we have much more of life and vigour, as well as of ease and fluency. There is often, also, a good deal of animation, and of descriptive luxuriance, in our popular metrical romances, the era of which nearly coincides with that of the stage of our language now under consideration, or the period between the middle of the thirteenth century and the middle of the sixteenth, the period of Middle English, as it may be designated, as standing between that early condition of the language, in which it had not yet begun to receive any intermixture of French, and the completion of that intermixture. Much prose also was written from the middle of the fourteenth century, if not from an earlier date. There were, for instance, the Travels of Mandevil, some tracts by Chaucer, the translation of Higden's Polychronicon by

John de Trevisa, Wiclif's version of the Scriptures and other writings, all of the fourteenth century; and afterwards a crowd of works of all kinds, of which perhaps the prose romances that now came into fashion, taking the place of the verse originals from which they were drawn, were among the most remarkable. But the predominating style and spirit of all writing still continued to the close of this period to be essentially barbarous and grotesque. One work only is an exception, the 'Canterbury Tales' of Chaucer.

3. This work is one of the chief glories of our English literature, and one of the marvels in the literature of the world. At a date when nothing else had yet been produced among us that was not more or less of a barbarous character, and nearly two centuries before any other English poetry was written that still continues to be read, it presents an example of such artistic execution as in its kind has not been surpassed to this hour. The style of Chaucer in the 'Canterbury Tales' is as perfect as anything in the language. We may have some higher poetry than his; we have no better writing. His English is in some respects different from ours, both in its vocabulary and its grammar, and it may seem to us to be a ruder form of the language, though that is probably only because we are strange to it, for it would be hard to show that it is really either less regular in its structure, or less complete, at least for the purposes of poetry, than that now in use; but no later English, however more polished it may be deemed, is made by any succeeding writer to do the work of expression either more successfully or with more apparent ease than this of the fourteenth century is by Chaucer. Many of his words and inflections are now obsolete; but otherwise his diction has nothing more about it of rudeness or barbarism than has that of Homer or that of Virgil, of both of whom also the language is to a much greater extent than in his case antiquated and dead. Nor has there ever been a greater master of the art of narrative. The period in

which he lived, it is true, could not but reflect its own colour upon his genius and the creations of his fancy; he belongs neither to classic antiquity nor to modern times, but to the middle ages, and the spirit of his poetry must of necessity be mediæval and what is called Gothic. But that does not necessarily exclude the artistic spirit. Chaucer may be regarded as the inventor of artistic writing in English, the first who introduced into our tongue that pervading life and light of composition, caught from the refined and brilliant writers of Greece and Rome, which first Dante, and afterwards Petrarch and Boccaccio, had already exemplified in Italian; and he may consequently be accounted the true founder of our National Literature.

4. Chaucer wrote much more poetry besides the 'Canterbury Tales,' and also, as already mentioned, some prose; but, although everything that he has left us is irradiated and enlivened by an active and graceful fancy, nothing else that he did belongs, properly speaking, to our living literature except that work of his old age. It is of great length, extending, although unfinished, to above seventeen thousand lines in verse, besides a considerable quantity of prose. The tales are of every variety of species, some stately and epic, some familiar and of everyday life, some tragic or sad, some light and comic: the qualities by which they are pre-eminently distinguished are narrative skill, dramatic vivacity, clearness and brilliancy of description, shrewdness of observation, satiric wit, humour, and pathos.

5. The form of the poetry is also remarkable. English verse was originally constructed upon the principle of alliteration; that is to say, it was required that in every line, or couplet, or stanza, the words or syllables occupying certain places should all begin with the same letter. This was almost the only kind of verse known to our ancestors before the Norman Conquest, or in what are called the Anglo-Saxon times; and it continued to be the kind in frequent use down to the

age of Chaucer. The poem called the 'Visions of Pierce Ploughman,' for instance, which belongs, as well as the 'Canterbury Tales,' to the latter half of the fourteenth century, is in alliterative verse. This was also the old principle of versification both in the Scandinavian and in the Celtic tongues. In the French, Italian, and other tongues formed from the Latin, or Romance tongues as they were called, the constituent of verse had long been that consonance, or agreement in sound, of the final syllables, which we call rhyme. This took the place in those modern languages of the south of Europe of that regulated arrangement of long and short syllables upon which verse had depended in their parent Latin. Rhyme had been introduced into English poetry long before the time of Chaucer; all the verse both of Robert de Brunne and of Robert of Gloucester is rhymed. There are even traces of rhyme in the last age of what is called the Anglo-Saxon period. It had come in apparently with the first knowledge of the literature of the Romance tongues, as soon as translation began from the Norman French or the Provençal, and before there was much or scarcely any actual intermingling of the former in the common speech of England. Still it continued to be looked upon as an innovation—a deviation from and violation of the old usage and genius of the language.

6. All Chaucer's verse is in rhyme. In adopting that form of writing he turned his back upon the purely Gothic condition of his native tongue, and as it were proclaimed his adherence to the new school which aimed at reforming it by cherishing and promoting the tendency of its old substance or basis to combine with another element, the French brought in by the Conquest. Chaucer was not the founder of this school, but he became its leader,—in that, however, only following and guiding the course which the language was naturally and inevitably taking. In one matter he appears to have had no predecessor. Nearly all the verse of the 'Canterbury Tales' is of the kind which is

now commonly known as the English heroic line, from its having come to be that in which most compositions of a more elevated or elaborate character are written; and it is in that work, as far as is known, that we have the first example of its employment. It had been long used both by the French and Italian poets; and from them, no doubt, Chaucer borrowed it. In what may now be called its normal or customary form with us it consists of ten syllables, an unaccented eleventh syllable being only occasionally ventured upon, making what is called a double rhyme; in French and Italian, from the nature of those languages, it ran more habitually into eleven syllables, and that is probably also the true length of most of Chaucer's lines, although they generally admit of being reduced without injury to the ordinary standard by the mere suppression of the final *e*, which was pronounced as a distinct syllable in his day but is now silent,—as in the case of such words as *tim–e*, *Rom–e*, which were dissyllables with him, though only monosyllables with us. Chaucer's heroic lines, if they may be so called, are sometimes interlaced so as to form stanzas, but are most usually in distichs or couplets.

7. After the 'Canterbury Tales' of Chaucer we have nothing that can be said still to form part of our living literature till we come down to Spenser, whose era is later than that of Chaucer by about two centuries. The century and a half that followed the death of Chaucer is a blank in English poetry; although the greatest of the old Scottish poets, Dunbar, belongs to the earlier portion of that time. Its close was marked in England by the verses of Lord Surrey and Sir Thomas Wyatt and Thomas Sackville (afterwards Lord Buckhurst and Earl of Dorset); but they were all destined to be very soon forgotten by everybody but curious inquirers into the antiquities of our literature. Their appearance was at most only the breaking of the dawn.

8. The new day came with Spenser. He regarded

himself as the disciple and poetic son of Chaucer; and to some extent he is certainly an imitator of his great predecessor. He began by attempting (in his 'Shepherd's Calendar') to revive even the language, and what he imagined to be the peculiar versification of the illustrious father of our poetry. At a later date his 'Mother Hubbard's Tale,' the product of a far higher spirit of imitation, might almost be said to give us Chaucer himself, as the old poet of the fourteenth century would have written if he had lived in the sixteenth. And there is more or less of the same inspiration in others of Spenser's minor pieces, all of which also have in them enough of independent life to secure them from ever becoming uninteresting to the lovers of poetry, and some of which, such as his 'Colin Clout's Come Home Again' (in celebration of a visit in Ireland from his friend Raleigh, the Shepherd of the Ocean, as he is designated), the 'Four Hymns' (in honour of Love and Beauty, Earthly and Heavenly), and the 'Epithalamion' (or Nuptial Song) on his own marriage, are among the brightest gems of our literature.

9. But there is little or nothing of the inspiration either of Chaucer or of any other English predecessor to be discerned in Spenser's greatest work, his 'Fairy Queen.' Even from Sackville, who had preceded him in allegorical poetry, he cannot be said to have learned any of his style or manner. He was more indebted to the recent poetry of Italy, to Ariosto and Tasso, the latter of whom was his contemporary. The first three books of the 'Fairy Queen' were published in 1590, three more in 1596, and the fragment of a seventh book, not till some years after the author's death, which took place in 1599. The poem was to have consisted in all of twelve books: unfinished as it is, it extends to the length of between thirty and forty thousand lines. The 'Fairy Queen' is in every way one of the greatest works in the poetical literature of the world. In our English literature, it stands perhaps more distinctly and conspicuously alone than any other poetical work that we

possess. There is nothing else in the language that at all resembles it, unless it may be one or two avowed imitations. Even the form of the verse is peculiar, an invention of Spenser's own, and still known as the Spenserian stanza.

LESSON III.

SHAKESPEARE.

1. THE 'Fairy Queen' alone would have more than doubled the poetical wealth of which the language could previously boast; the dramatic works of Shakespeare, another product of the same age, made it richer than any other tongue, modern or ancient. Shakespeare probably began to write for the stage about 1590; he died, at the age of fifty-two, in 1616; and all his plays had been given to the world through the press by the year 1623. Thirty-nine in all are commonly attributed to him; but doubts have been started as to four or five of them. Shakespeare was not our earliest dramatist; but there is no earlier whose works are now cared for, except as curiosities. While his are more read than anything else in the language, theirs are not popularly known at all. He did not continue the structure which they had begun, but rather commenced another for himself; and he is properly the founder of our poetical drama, as well as the writer by whom it has been carried to the greatest height and perfection. Shakespeare's blank verse, also, is so great an improvement upon any that had been previously written, that it may almost be regarded as his own invention; though blank verse, first introduced by Lord Surrey, whose death took place in 1547, in a translation of the second and fourth books of Virgil's Æneid, had since been employed by various writers, both dramatists and others.

2. Meanwhile lyric and other minor poetry had already been produced in great abundance, and some of it such as has retained a place in our literature. Lord Surrey and Sir Thomas Wyatt had at least set the

example of careful finish in writing of this order; Sir Philip Sydney added deeper passion, and also more subtlety both of thought and of expression; and, if even his tender and graceful sonnets have not retained their hold of the general mind, there are those both of Spenser and of Shakespeare, whose names alone are enough to consecrate and immortalize whatever they have left us. Shakespeare had also given to the world, besides his dramatic works, his poem of 'Venus and Adonis' in 1593, and that of 'Tarquin and Lucrèce' in 1594.

Then, among a crowd of dramatic writers who were contemporary with Shakespeare, at least Ben Jonson, and Beaumont and Fletcher, had produced some works which, as well as all of his, were permanent additions to the literary wealth of the language.

3. And great things had also already been done among us in prose. The birth of English prose composition dates, as already noted, from about the middle of the fourteenth century, when the Travels of Mandevil were followed by Trevisa's translation of Higden's Polychronicon, the prose portions of the 'Canterbury Tales,' with other pieces by Chaucer, and a complete version of the Scriptures both of the Old and New Testament, besides many theological tracts, by the reformer Wiclif and his followers. Beginning also about the same time, a succession of prose romances, and soon after another of national histories, styled 'Chronicles,' went on nearly throughout the fifteenth and sixteenth centuries. But none of all this earlier prose can be said to have survived its own era. Nor can we reckon as still living, or as forming any part of our existing literature, either the new translation of the Bible by Tyndal, which appeared in the first half of the sixteenth century, or any of the theological and polemical writings of Cranmer, Ridley, and others of the reformers in the next age, or even some works of Sir Thomas More, Sir Thomas Elyot, Roger Ascham, and others, evidently composed with a principal regard

to correctness and finish of style; and still less either the flowing and lively satirical effusions of Thomas Nash, or the more elaborate and ambitious eloquence of John Lyly (commonly called the Euphuist) and his imitators. Nay, even the rich but somewhat too artificial beauty and splendour of Sydney's 'Arcadia, and 'Defence of Poesy,' and the graphic vigour of Spenser's 'View of Ireland,' and the theological writings of Bishop Hall, and Bishop Andrews, and Dr. Donne, full as they are of all that is ingenious and striking and brilliant, may be regarded as having, either from change of taste, or in some cases from the altered circumstances of the subject, ceased to be generally interesting or attractive.

4. The same thing may be said of Raleigh's 'History of the World,' for all the merits of its easy, manly, and often eloquent style, which is, perhaps, the most modern of its day,' unfinished as the work is, and completely superseded in respect of the information contained in it by later works. But, after all such deductions, there will still remain a considerable amount of prose written before the end of the first quarter of the seventeenth century which continues to be as much read as ever it was. There is, in the first place, our admirable authorized version of the Bible; it was originally published in 1611. There is Hooker's great work on 'Ecclesiastical Polity,' one of the chief monuments of English eloquence, the first portion of which appeared in 1594, and which is wholly the product of the sixteenth century, for Hooker died in 1600, although the last three books did not see the light till 1632. And there are the various works of Bacon, perhaps, upon the whole, in respect of style the greatest of English prose writers; his 'Essays,' first published in 1597, his 'Advancement of Learning' in 1605, his 'History of Henry VII.' in 1622, besides many shorter pieces.

5. To such height, then, had the permanent fabric of our national literature been already built up more than

two centuries ago. The whole, it is to be noted, was the doing of two distinct periods of time, separated from each other by a long interval, and each in itself of very limited extent: what we may call the foundation of the edifice had been laid by Chaucer, in the latter end of the fourteenth century; the superstructure had been the work of Spenser and Shakespeare and Bacon, and a few other writers of we may say the last decade of the sixteenth century, and the first quarter of the seventeenth. And, as the first of these two brief periods of sunshine and productiveness was followed by the contest for the throne between the Houses of York and Lancaster, and the great social convulsion of the Wars of the Roses, so the second brings us down to the eve of our next civil war, that which broke out between the Crown and the Parliament under Charles I.

If the growth and increase of English literature had stopped here, or if, as happened to the Romans after the Augustan age, little or nothing more had ever been produced among us except what could only be accounted as of the quality and the worth of silver or brass, in comparison with the gold of the preceding time, it would still have been entitled to take rank with any other literature in the world. No other language, the modern or ancient, can boast of prouder names, or loftier performances, than those of Chaucer, Spenser, and Shakespeare in verse, and Bacon in prose.

6. Nor in the two centuries and more, that have since elapsed, has the structure been carried to a greater altitude. But it has been largely extended in every direction, and has received some additions that have added not only to its magnitude but to its magnificence.

First of all, and above all else, there is the poetry of Milton. Milton's 'Comus,' and some of his minor pieces, had been previously published; but it was not till the latter half of the seventeenth century, after the storm of the civil war had passed away, that he produced his great works of 'Paradise Lost' and 'Paradise Regained.' Our language, already so rich in other kinds of poetry, was now possessed of an epic poem with which certainly there was no other in any language that could dispute the palm of superiority, if it were not the 'Iliad' alone. Much of the spirit of Milton's poetry is of foreign derivation—from modern Italy, from ancient Greece and Rome, and especially from the Hebrew Scriptures; but, in so far as it is English, he may be regarded as, more than of any other of his great predecessors, the disciple and follower of Spenser: They both also drank to a considerable extent at the same fountains of foreign learning and song. The blank verse of 'Paradise Lost,' however, would connect its author rather with Shakespeare, in so far as it is not to be considered distinctive of his own peculiar taste and genius. He and Shakespeare, different as the blank verse of the one is from that of the other, are beyond all question the two writers by whom, each after his own fashion, the powers of that kind of verse have been best brought out; indeed, there can scarcely be said to be in the language any other dramatic blank verse than Shakespeare's, or any non-dramatic except Milton's, that is very satisfactory. Whether in blank verse or in rhyme, Milton's is the most richly and variously musical poetry in the language. His 'Lycidas' is perhaps the finest strain of music ever composed of articulate words. Our finest English sonnets, also, are those of Milton.

7. Chaucer, Spenser, Shakespeare, and Milton are the royal names in our literature; there are no others of equal rank. Some of later date, however, are of all but the very highest eminence; and the last two hundred years have added to the stores of the language a large mass both of poetry and of prose eloquence, much of it of the first order of brilliancy, in forms or kinds that either had been scarcely or not at all known among us before, or had been cultivated with only inferior success.

8. As Shakespeare is the great poetic light of the

beginning of the seventeenth century, and Milton of the middle, so that of the close is Dryden. Shakespeare died in 1616; Milton in 1674; Dryden lived till the year 1700. In purely didactic verse, and in satirical invective, Dryden had not been equalled by any preceding writer, and his declamatory splendour has not been surpassed in our subsequent poetry. His 'Absalom and Achitophel,' 'Hind and Panther,' and others of his pieces, afford perhaps the most remarkable examples yet to be found in the language of the movements of a writer in verse being apparently rather aided than impeded by his fetters or trammels. The older he grew, too, the gayer his fancy seemed to become, as well as the more complete his mastery over his language. A volume published in his seventieth year, the last of his life, contained, besides much more of the most spirited writing he ever produced, his exquisite 'Flower and Leaf,' the one of all his poems in which both the colouring and the music are the richest and most perfect, and also his 'Alexander's Feast,' the bright flow of which has a life like that of running water sparkling and flashing in the sunlight, and which looks and sounds as if it would be the last poetry in the language to feel the touch of time.

9. Another poet of this date who has not grown old is Butler, the author of 'Hudibras.' This is the more remarkable, inasmuch as the poem might be said, almost beyond any other that was ever written, to have sprung out of the events and peculiar circumstances, and to be addressed more especially to the passions, of its own day. But that, after all, is and must be the case, more or less, with all poetry, and all powerful writing. The satire of 'Hudibras,' for the originality, the abundance, and the unflagging life of its wit and humour, stands alone in our literature.

10. A host of other poetical writers of the seventeenth century, that were admired and popular in their day, have now almost faded from the view of the generality of readers,—Donne, Cowley, Davis, Waller, Denham, Carey, Lovelace, Suckling, Sedley, Wither, Marvell,

Browne, Fanshawe, &c.,—beautiful as many things that they have left us are. They have been extinguished to the common gaze as the stars are in the daylight.

Much prose was also written in this century, subtly by Donne, and grandly by Milton, and quaintly by Fuller, and picturesquely by Sir Thomas Browne, and weightily by Barrow, flowingly by Clarendon, and luminously by Hobbes, and gracefully by Cowley, and vivaciously by Dryden; but the prose eloquence that has made the greatest impression upon later times is that of Bishop Jeremy Taylor. It is often as imaginative and gorgeous as any poetry.

LESSON IV.

EIGHTEENTH CENTURY.

1. Of the first half of the next century, the eighteenth, the ruling poetic luminary was Pope. He lived till 1744, and had been before the world as a poet for between thirty and forty years. Indeed, he may be affirmed to have been, by universal acknowledgment, the chief English living poet ever since the publication of his 'Essay on Criticism,' in the year 1711. It is true that he had no formidable rivals, fewer than even Dryden had had in the preceding age; the busy song from so many voices which had filled the air in the days of Elizabeth and James had been ever since subsiding, and in those of Anne and the first Georges the competition had almost died away altogether. But the voice of no other poetry had ever been heard in England that could have prevented that of Pope from being listened to with admiration. He was the worthy successor of Dryden, on whom he may be considered to have formed himself, and to whose style and manner, if he fell somewhat short of its ease and freedom and impetuous force, he added a uniformity of finish and elegance which often doubled its brilliancy and effect. The poetry of the one more resembled a natural landscape; that of the other was like the same ground laid out and

decorated by the transforming hand of art. If something was lost, something was also gained. The high polish which Pope aimed at in his verse at any rate gave it more of novelty and peculiarity of character. It was undeniably a kind of poetry such as the language did not before possess, and as distinguishable from any other as that of any one of his greatest predecessors. On the other hand, perhaps no one of our other great poets has exercised more influence upon the versemaking of succeeding times than Pope has done, and that not by any means in the case only of those writers who may be regarded as being his imitators or of his school.

2. Even his contemporaries, Thomson and Young, probably caught something from his example, although they had certainly both mainly formed themselves on other models. Pope's reputation was established before either made himself much known. Young's style in his 'Night Thoughts' is more artificial than Pope's is anywhere; yet the earnest tone of the work, together with the high interest belonging to its subject, has given it a strong hold upon the hearts of readers of very varying tastes and degeees of literary cultivation. It is, in fact, our chief poetical work of a purely and professedly religious character. Thomson's poem of 'The Seasons,' again, is the poetical Bible, as it were, of all lovers of nature. And, his 'Castle of Indolence,' written in imitation of Spenser, is at once the happiest of imitations, and one of the most delicious poems in the language, or in any language.

3. More of Pope is to be traced in Goldsmith's two charming poems, 'The Traveller' and the 'Deserted Village,' the style and spirit of which are, however, made distinctive by a directness and cordiality, and many touches of natural grace, that are all his own. Nor probably would either Collins or Gray have written exactly as they did had not Pope preceded them. Yet the poetry of both the one and the other is eminently peculiar and original in its general tone and character, more especially that of Collins, whose best odes, that

entitled 'The Passions,' that on the 'Superstitions of the Highlanders,' and that 'To Evening,' are unrivalled for their union of fire and delicacy of imagination with the richest music and the most exquisite perfection of finish. Gray, more elaborate and gorgeous, has less of native life; but his poetry, besides its imposing splendour, has often a meditative tenderness which makes its way to all hearts, as the enduring and universal popularity of his famous 'Elegy' abundantly attests.

4. A more natural and simple style of composition was exemplified by Shenstone, and Thomas Warton, and Beattie, whose 'Minstrel' continues to be a general favourite. On the other hand, the artificial manner of Pope was exaggerated by Johnson in his two imitations of Juvenal, entitled 'London,' and the 'Vanity of Human Wishes;' and, with less rotundity and robustness, and more of fancy and point, was at a later date carried to the last excess of extravagance by Darwin in his 'Botanic Garden.'

5. The accessions which our poetry received in the course of the eighteenth century were equalled in amount by the additions that were made to our prose literature; and some kinds of writing which had been little or scarcely at all attempted among us previously were now actively cultivated. Addison began the new era, with his easy, clear, and graceful expression, and his fine humour. Swift followed, with his coarser but stronger pen, and far more powerful and diversified genius, in his 'Examiners' and 'Draper's Letters,' and other political pieces, in his 'Gulliver's Travels,' and above all in his 'Tale of a Tub,' the richest comic satire in the language. Then the fashion of style took to growing more and more ornate and ambitious; first with Bolingbroke, who, without having much thought or matter that has continued to be held in estimation, outshone Swift in polish and refinement of expression, and both him and Addison in rhetorical rhythm and cadence: next with Johnson, the rhythmical character of whose writing is much more marked and sonorous;

then with the author of the 'Letters of Junius,' in whose manner antithetic point is a still more abundant ingredient; lastly with Gibbon, with whom every form of the artificial and anti-natural in diction is incessant. Johnson and Gibbon in prose may be said to stand in the same relation as Pope and Darwin in verse.

6. Gibbon's great work, however, 'The Decline and Fall of the Roman Empire,' presents a wonderful combination of laborious erudition with brilliancy of execution, and still stands incontestably the chief boast of the language in the department of history. And the same age added to our literature the History of England by Hume, and those of Scotland, of America, and of Charles the Fifth, by Robertson. Hume and Robertson were both natives of Scotland. Robertson, though his style wants raciness and colour, is always luminous and dignified; Hume is one of the greatest masters of narrative in any language. He and his countryman Adam Smith, the author, besides other works, of the celebrated treatise entitled 'The Wealth of Nations,' which may be said to have almost created the science of Political Economy, are also remarkable for the natural character of style which they both preserved during the general prevalence of the artificial and rhetorical school.

7. This, too, is the age of our great English novelists: Defoe and Richardson, Fielding and Smollett, Sterne and Goldsmith. 'Robinson Crusoe,' 'Clarissa Harlowe,' 'Tom Jones,' 'Roderick Random,' 'Tristram Shandy,' and 'The Vicar of Wakefield,' are still among the most renowned and universally familiar works in the language.

8. But the greatest of the English prose writers of the eighteenth century is Burke. He fills the latter half of that century with a splendour similar to that which Bacon sheds over the first quarter of the preceding one. Each is equally great as a writer and as a thinker, and their works are as full of wisdom as of eloquence. Those of Burke are the chief storehouse of political

philosophy in our literature. And no where else is profound philosophy so impassioned and so brilliant. Burke's most remarkable productions are, besides his 'Vindication of Natural Society' (an imitation of Lord Bolingbroke) and his treatise on the 'Sublime and Beautiful,' both published in 1756, when he was only in his twenty-sixth year, his 'Thoughts on the Present Discontents' (1770), his 'Reflections on the Revolution in France' (1790), his 'Appeal from the New to the Old Whigs' (1792), his 'Letter to a Noble Lord on his Pension' (1796), and his 'Letters on a Regicide Peace' (1796 and 1797), with sevetal speeches delivered at various times in the House of Commons and elsewhere, and afterwards sent to the press by himself, or printed since his death from his papers. He died in 1797.

Burke ushers in a new era in our prose literature. All our subsequent prose writing takes something of its character from his. A similar inspiration of new life was given to our poetry by his contemporary Cowper.

9. Cowper was born the year after Burke. His first published poetry, however, with the exception of a few Hymns without his name in the Olney collection six years earlier, did not appear till 1782. He lived till 1800. Cowper, like every other English poet who had arisen since the time of Pope, had learned a great deal from that master; he would have written very differently had Pope not preceded him; but still he may be looked upon as more properly the successor of two other writers,—Churchill and Cleveland. Cleveland was the great royalist poet and satirist of the time of the Commonwealth; he died, at the age of forty-five, in 1658. Churchill was born in the same year with Cowper, but he was suddenly cut off, at the age of thirty-three, in 1764. The distinction of the manner adopted by Cowper is a preference for the vigorous and expressive over the merely polished and graceful. His example restored more of directness, simplicity, and nature to our poetry. Nothing that he wrote is likely

to be forgotten; and his 'Task' especially is one of the poems that are dearest to the national heart. Cowper is also, in his Letters, among the most charming of our prose writers, as are also his predecessors Goldsmith and Gray.

10. The impulse of renovation which English poetry received at this time, was materially aided by the example of the great modern poet of Scotland, Burns. Burns was born in 1759, published his first volume of poems in 1786, and closed his short life ten years thereafter. Although he did not write in the standard language of the country, his poetry, which at once took the universal heart of Scotland by storm, was too remarkable, and the noise which it made in its own region too loud, not to arouse attention in England also. And to whatever extent a voice of nature so free, fresh, and strong penetrated men's hearts, it could not but tend to break up whatever was too artificial or purely conventional in the prevailing modes of thought and expression, and to animate them with new warmth and fire.

11. It is strange to think, that we should still, in the present year 1855, have living among us a poet who made his first appearance in print in the same year with Burns. Mr. Samuel Rogers, the distinguished author of 'The Pleasures of Memory' and 'Italy,' began his career of authorship in that year, 1786, with a thin volume containing 'An Ode to Superstition, with other Poems.' Nor was he then a very young man; Burns and he would be about the same age. Mr. Rogers, however, must be regarded as belonging in the main to the school of Pope; although his polished and graceful verse too is indebted for something of deeper tenderness and more varied modulation than it might otherwise have had to its having been matured in the light of a later era.

12. Of that era, extending to our own day, the great names are familiar to all. Byron and Scott, Wordsworth and Southey, Coleridge and Shelley, Crabbe and Campbell and Moore, would alone have made it the

most remarkable period in the history of English poetry for splendour as well as productiveness after the age of Spenser and Shakespeare. And when there are also Keats, in whose remains the ore is so rich, and Hood, in whom the gold is so fine; and Hemans and Baillie, and Wilson and Tennant, and Hogg and Talfourd, and others, among the dead; and, among those who still survive, Hunt and Tennyson, the Brownings and Bayley, and Milnes and Milman, and Procter and Archer, and Taylor, and many more; who have each added to the stores of their native tongue more or less, of what is not likely ever to be suffered to perish. In prose, again, there are, besides Scott and Campbell, and Coleridge and Southey and Moore, whose poetry makes their chief fame, Godwin and Edgeworth, and Austen and Marryat, and Lamb and Wilson, and Sydney Smith and Hazlitt, and Jeffrey and Mackintosh, and Stewart and Hall, and Chalmers and Mitford, of those who are gone; and De Quincy and Landor, and Macaulay and Carlyle, and Bulwer and Martineau, and Dickens and Thackeray, and Fonblanque and Forster, and Lewes and Helps, and Hamilton and Thirlwall, and Napier and Grote, to mention only a few of many, who yet remain to instruct and delight us.

13. Nor in any survey of what English literature has now become ought the authorship of our brethren of the same blood and the same speech on the other shore of the Atlantic to be forgotten. Their Irvings and Emersons, their Prescotts and Bancrofts, their Coopers and Hawthornes, their Poes and Longfellows, are ours as well as theirs. The literature to which a work of genius belongs, and of which it makes part, is that of the language in which it is written. The part of the world in which it may have been composed, or the country in which the writer may have been born, is immaterial. Their common tongue, the result of their common descent, must ever keep the English and the Americans essentially one people. Such bonds,—"lighter than air, but stronger than iron," as Burke

has finely described them—no revolution, no political separation, can destroy. Nor need it be apprehended that the English language will gradually change and become corrupted in America; the probability rather is that it will speedily work off whatever of provincial peculiarity it may have acquired, and be written with more and more purity, till little or nothing shall remain, in the style or idiom at least of any writer of the first class, to indicate whether he is an American or an Englishman.—George Craik.

LESSON V.

THE TRIUMPHS OF OUR LANGUAGE.

Now gather all our Saxon bards,
  Let harps and hearts be strung,
To celebrate the triumphs of
  Our own good Saxon tongue;
For stronger far than hosts that march
  With battle-flags unfurled,
It goes with *freedom*, *thought*, and *truth*
  To rouse and rule the world.

Stout Albion learns its household lays
  On every surf-worn shore,
And Scotland hears its echoing far
  As Orkney's breakers roar—
From Jura's crags and Mona's hills
  It floats on every gale,
And warms with eloquence and song
  The homes of Innisfail.

* * * * *

It spreads where winter piles deep snows
  On bleak Canadian plains,
And where, on Essequibo's banks,
  Eternal summer reigns:
It glads Acadia's misty coasts,
  Jamaica's glowing isle;
And bides where, gay with early flowers,
  Green Texan prairies smile.
It tracks the loud swift Oregon
  Through sunset valleys rolled,
And soars where Californian brooks
  Wash down their sands of gold.

It sounds in Borneo's camphor groves,
On seas of fierce Malay,
In fields that curb old Ganges flood,
And towers of proud Bombay:
It wakes up Aden's flashing eyes,
Dusk brows and swarthy limbs—
The dark Liberian soothes her child
With English cradle hymns.

Tasmania's maids are wooed and won
In gentle Saxon speech;
Australian boys read Crusoe's life
By Sydney's sheltered beach:
It dwells where Afric's southmost capes
Meet oceans broad and blue,
And Nieuveld's rugged mountains gird
The wide and waste Karroo.

It kindles realms so far apart,
That while its praise you sing,
These may be clad with autumn's fruits,
And *those* with flowers of spring:
It quickens lands whose meteor-lights
Flame in an Arctic sky,
And lands for which the Southern Cross,
Hangs its orbed fires on high.

Mark, as it spreads, how deserts bloom,
And error flies away,
As vanishes the mist of night
Before the star of day!
But grand as are the victories
Whose monuments we see,
These are but as the dawn which speaks
Of noontide yet to be.

Go forth, and jointly speed the time,
By good men prayed for long,
When Christian states, grown just and wise,
Will scorn revenge and wrong:
When earth's oppressed and savage tribes
Shall cease to pine or roam,
All taught to prize these English words—
Faith, *freedom*, *heaven*, and *home*.

J. G. Lyons.

ETYMOLOGICAL AND EXPLANATORY APPENDIX.

By C. W. Connon.

MENTAL CULTURE.

LESSON I. (p. 7.)

Absurdity—comes from a Latin word signifying "deaf," and would primarily apply to an answer given by a deaf man. As if you were to ask your way to the Exchange, and he answered by telling you that it was two o'clock; hence anything opposed to reason or common sense.

Academus—a grove in the vicinity of Athens, where the illustrious philosopher Plato used to give his instructions, and hence a place of instruction generally, a school of philosophy, or a society of learned men.

Accessible—and *accession*, from Latin Cedo, *I come*, and Ad, *to*, mean respectively, "what may be approached," and addition, increase, or augmentation.

Antecedent—what goes before something, and which may or may not be connected with it. *Consequent* is what follows after.

Apostle—from two Greek words, means literally, "one sent away;" but the word is now confined to the twelve disciples who were originally appointed by our Lord to preach the Gospel. *Missionary*, as far as the root of the word goes, would mean exactly the same thing, though it is somewhat differently applied.

Approbation—from the Latin Probus, *good*, means the act of expressing satisfaction with anything that another has done, and pronouncing it *good*.

Artificial—what is made by the work or art of man in opposition to what is produced by nature.

Confidence—and *diffidence*, are from the same root, Fides, *faith*. I have confidence in a person when I can *trust* him to do anything. I am *diffident* of myself, and do not attempt what I am not sure that I can do.

Consciousness—is defined as being "The act of attending to what is passing in the mind at the time."—ABERCROMBIE. We are *conscious* of our internal states of body or mind. We *perceive* what takes place without ourselves.

Constitution—means the established form of government in a country.

Conversation—now means familiar intercourse and unrestrained talk between two or more persons, but originally the whole conduct of a man, and is so used in the New Testament. "Let your conversation be such as becometh the Gospel." And again, "Be ye holy in all manner of conversation."

Encouragement—comes from the French Cœur, Latin Cor, the *heart*, and means the act of inspiring with courage to attempt anything.

Geometry—from two Greek words, would mean, literally, "the measure or the art of measuring the earth," but it now means the science of magnitude in general, comprehending the doctrines and relations of whatever is susceptible of augmentation or diminution. Euclid's Geometry is the most generally recognized text-book on the subject.

Ingenuous—ought to be carefully distinguished from *ingenious*. The former refers to the moral character, and means "open-hearted;" the latter relates to the intellect, and means "clever."

Innate power—is power born along with us, power for which we are not indebted to any external cause.

Infancy—"Infant" literally means "one who does not speak;" but in use its meaning is restrained to "one who is not able to speak from youth." *Infancy* is the period of human life that precedes childhood.

Invigorating—from the Latin Vigor, *strength*, means causing to be strong.

Investigate—is to trace up step by step or to follow up carefully, from the Latin Vestigium, *a footstep*.

Oral—from Os, Oris, *the mouth*, relating to the mouth.

Pertinent—what really belongs to the subject. A pertinent question is one that is really connected with the subject in hand. *Impertinent* would literally signify the opposite of this, but it takes a secondary sense along with it, and means generally, in addition, that the question is a rude or impudent one.

Stimulate—to spur on, from the Latin Stimulus, *a spur*.

Stoics—the ancient, were a celebrated sect among the Greeks. They encouraged a stern and unbending virtue, and a contempt for pain and suffering.

Superficial—what relates to the superficies or surface of any body. "A superficial glance" is opposed to "a thorough examination," or "minute survey."

LESSON III. (p. 14.)

Alfred—one of the most famous kings of England, was born in 849, and succeeded to the throne in 871, and his reign extended to the end of the century.

Amuse—from the Latin Musa, *the Goddess of Study*, &c. To *amuse* is, literally, to take one from study or any serious employment.

Ancestors—from Ante, *before*, and Cedo, *I go*, are those who have gone before us, *i. e.*, our forefathers.

Brand—a mark made by a hot iron, and hence any distinguishing mark.

Cabinet—a piece of furniture, consisting of a chest or box with drawers and doors—generally used for holding something valuable. The word has other meanings.

Credibility, from Credo, *I trust*, means the fact or state of being able to be trusted. It is the abstract noun from the adjective credible—what can be trusted.

Degrade—from De, *down*, and Gradus, *a step*, means to take anything down a step lower than it was. To *elevate* is the opposite of *degrade*.

Descended—from De, *down*, and Scando, *I climb*, is to come down from a place. "Ascend" is to go up.

Disseminate—comes from the Latin Semen, *a seed*, and to disseminate is to scatter abroad as seeds are scattered either by the hand of man or by autumnal winds.

Edible—from Edo, *I eat*, what is fit to be eaten and good for food.

Eloquent—from the Latin E, *out*, and Loquor, *I speak*, means having the power to move men by speech or writing.

Examine—from the Latin Examen, *the tongue of a balance*; to bring anything to a test so as to see what it really is.

Funeral—comes from the Latin Funus, *a rope*, from the rope or torch that was borne at the burial to set fire to the pile on which the body was to be burned. We retain the word, as meaning burial, after the custom which gave rise to it is gone.

Heritage—From the Latin Hæres, *an heir*, is the same as inheritance, and means the right of succeeding to property on the death of a father, &c. It also means the property itself.

Indolence—is, literally, *the natural disposition*, but as most people are inclined to do as little as they can it comes to be synonymous with laziness. Indolence and ennui are just Latinized and French terms for the honest old Saxon word laziness.

Instinct—the mysterious power by which animals, previous to instruction, do certain things for their own preservation or the continuance of their species.

Invention—from the Latin Invenio, *I find out.* "We invent things that are new; we discover what was before hidden. Galileo invented the telescope; Harvey discovered the circulation of the blood."—Blair.

Magic—the art of the Magi, certain Persian philosophers who were thought to have supernatural powers, and through the aid of spirits able to do anything. The word now means wonderful powers of any kind; and the old idea of spirits is utterly discarded by intelligent men, though it still lingers among the ill-educated and the vulgar.

Panoply—from two Greek words signifying *whole* and *armour*, means a complete armour of defence. The apostle Paul says, "Take unto you the *whole armour* of God." In the Greek the word *panoply* is used.

Paragraph—from two Greek words signifying *near* and *writing*, means a distinct part of a discourse or writing;—thus, the passage marked 8 on p. 19 is a paragraph.

Participate—from the Latin Pars, Partis, *a part*, means to share in a thing.

Perverse—from the Latin Per, *through*, and Versus, *turned*, means *turned aside or upside down*, hence, turned from the right course and obstinate in the wrong.

Peter—commonly called *Peter the Great*, was born in 1672, and he died in 1725, after laying the foundation of the Russian empire.

Printing—the invention of the art is generally attributed to Lawrence Koster, of Haarlem in Holland, in 1440. The art was introduced into England by Caxton about 1471.

Sophistry—false reasoning, from the Greek Sophist; a term applied to certain logical quibblers in the time of Socrates.

Supersede—and *derogate*. To supersede is, literally, to *sit above*, and hence to supplant and take the place of. To *derogate* is, literally, to *ask down*. It was technically used *for repealing a law*, and hence it signifies to take from or to annul.

Transmitted—from Trans, *across*, and Mitto, *I send*, means what is sent over to us—time or space being understood.

Validity—is the abstract noun from the adjective *valid*, what is strong, powerful, or to the purpose. A "valid argument" is one that cannot be answered.

PHYSICAL GEOGRAPHY.

LESSON I. (p. 21.)

Accomplish—from Ad, *to*, Con, *together*, and Pleo, *I fill*, means to finish anything completely. An accomplishment is an acquirement not absolutely necessary, but yet highly becoming. To accomplish is often used in the sense of *execute* or *do*.

Aconcagua—the highest peak of the Andes, 23,910 feet high.

Ætna—is a celebrated volcano in the island of Sicily.

Annexed—from Ad, *to*, and Nexus, *tied*, means what is tied to or united with another thing. A figure or drawing is *annexed* to a description in writing to make it more intelligible.

Calculations—from the word Calculus, *a little shell*, means now *counting*, from the ancient practice of using pebbles or shells to assist the operation.

Canopy—comes from a Greek word signifying a *gnat*, and originally meant a covering over a bed to keep off that insect, but it is now generalized to mean a covering of any kind. The covering over a throne or the sky over our heads is now equally called a *canopy*

Compare—from Con, *together*, and Par, *equal*, is to bring things together, and see if they are equal.

Convex—from Con, *together*, and Vectus, *carried*, means rising on the exterior surface with a round form. The opposite of it is *concave*.

Cotopaxi—is one of the highest peaks of the Andes in South America. It is 18,858 feet high.

Defined—from De, *down*, and Finis, *an end*, a thing the ends of which are distinctly laid down. To *define* is to mark the limits of a thing. We give a *definition* of a word when we mark off its meaning and distinguish it from other words to which it bears any resemblance.

District—from Dis, *asunder*, and Strictus, *drawn or bound*, means a territory of limited extent bound by known lines.

Extend—from Ex, *out*, and Tendo, *I stretch*, is to stretch out. *Extension*, the act or fact of stretching out. *Extensive* is large, wide, &c. "The most extensive country in Europe is Russia."

Horizon—from a Greek word signifying *a mountain*, means the line that terminates our view. Greece is a mountainous country, and everywhere a mountain terminates the view. The old English word *bourn*, in the sense of boundary, is taken from the Saxon *bourne*, in Scotch *burn*, a small stream of water, this also being a natural boundary.

Intersected—from Inter, *between*, and Sectus, *cut*, means cut or divided into parts—crossed.

Mouna Roa—a mountain in the Sandwich Islands in the Pacific, 13,430 feet high.

Navigation—from Navis, *a ship*, is the art of conducting a ship from any one part of the earth to any other. To "circumnavigate" is, literally, to sail *round* the earth *in a ship*.

Pyramids—the word is said to come from a Greek word signifying *fire*, because they are somewhat in the shape of a flame of fire—large at the base and tapering to a point. Every one has seen prints of the Pyramids of Egypt. They are among the oldest structures in the world. It is not known when they were erected or why, but it is conjectured that they were intended as burying-places for the Egyptian kings.

Peak of Teneriffe—a celebrated mountain in one of the Canary Islands, on the west coast of Africa. It is 12,236 feet high.

Structure—from Struo, *I build*, means a building, such as a house, church, &c. An *obstruction* is, properly, a *building* that comes *in the way of* (such is the meaning of *ob* in Latin) of one so as to interrupt his vision.

Successively—from Sub, *under*, and Cedo, *I go*, means "one after another." Be careful to distinguish this word from *successfully*.

Telescope—from two Greek words signifying *at a distance* and *I look*, means an instrument that enables us to see objects at a distance. A spy-glass is another name for the same thing.

Tangent—from the Latin Tangens, *touching*, is a line that touches a circle, but does not cut it.

Vision—from Visus, *seen*, is the power or act of seeing.

LESSON II. (p. 27.)

Ammunition—from the Latin Ad, *to*, and Munitus, *fortified*, is anything that tends to the defence or fortification of a place. The term is now generally used to mean powder and shot exclusively.

Atlantic—as applied to a particular ocean, gets its name from Mount Atlas in the north-west corner of Africa, the base of which it washes.

Century—from the Latin Centum, *a hundred*, means a period of a hundred years. *Decade* is a period of ten years.

Cherished—from the Latin Carus, *dear*, is "to hold dear," and so to protect and guard against harm.

Companion—from the Latin Panis, *bread*, is, properly, one who takes bread with you.

Elapse—from Lapsus, *having slipped*, means to pass away.

Export—from Ex, *out*, and Porto, *I carry*, is to take raw material or manufactured goods *out* of a country. To *import* is to bring them in. We *import* raw cotton or wool and *export* cotton cloth or broad cloth.

Fragile—from the Latin Frango, *I break*, what is easily broken. "A fragile bark" is one that is easily broken by coming against, *e.g.*, rocks, shoals, &c.

Inhospitable—from Hospes, *a guest*, is one who does not entertain guests, but rather thrusts them from his door.

Longitude—is the distance of a place east or west of any other place. The ancients knew more of the earth in that direction than from north to south. From east to west they therefore called longitude and from north to south latitude. The terms are still retained, though we know that the earth is nearly round every way.

Maritime—from Mare, *the sea*, is of or belonging to the sea. We speak of the spirit of "maritime adventure," meaning the desire to make discoveries by sea.

Melancholy—is used both as a noun and as an adjective, meaning *a gloomy disposition or state of mind*, and sad or downcast. It comes from two Greek words signifying *black bile*, it being believed that the colour of the bile affected the disposition of the mind.

Promontory—from Pro, *forward*, and Mons, montis, *a mountain*, means a high piece of land jutting out into the sea

Prosecuting—from Pro, *forward*, and Sequor, *I follow*, means *following up* a thing. Distinguish between prosecute and persecute.

Recompense—from Pensus, *paid*, means the pay that one gets for doing anything.

Subsequent—from Sub, *under*, and Sequor, *I follow*, means "following after." *Previous* is the opposite term. I spoke in a *previous* chapter, and I will speak in a *subsequent* one.

The Ladrone Islands—were so called from the Spanish word Ladrone, in Latin, Latro, *a robber*, because the inhabitants were given to stealing.

LESSON III. (p. 33.)

Attraction—from Ad, *to*, and Tractus, *drawn*, is the power in bodies by which they draw each other together. Two corks floating in a basin of water have a tendency to go together. Why we cannot say, only such is the fact.

Constellation—from Con, *together*, and Stella, *a star*, means a group of stars taken together. Many of the clusters or groups are fancifully supposed to resemble animals, such as the Bull, the Ram, &c.

Cylinder—from a Greek word signifying *to roll*, the same as our word *roller*. It is round one way, but not all ways like a globe.

Diameter—from two Greek words signifying *through* and *a measure*, means a right line passing through the centre of a circle terminating in the circumference. It divides the circle into two equal parts.

Derive—from De, *down*, and Rivus, *a river*, means to draw from in a regular channel A conclusion is said to be derived from certain facts.

Disc—from the Latin Discus, *a quoit*, is the face or breadth of the sun or moon.

Eclipse—from a Greek word signifying *to fail*, means the darkening of one heavenly body by another passing over its surface. When the moon passes between us and the sun, the sun is said to be eclipsed, and when the earth passes between the sun and the moon, the moon is said to be eclipsed. It is the body *failing* in light that is eclipsed.

Experiment—from Experior, *I try*, means a trial. Observation and experiment are the great means of advancing our knowledge.

Immense—from In, *not*, and Mensus, *measured*, would mean what has not been measured; hence, what cannot be measured, hence, large, boundless, &c.

Inclination—from In, *into*, or *towards*, and Clino, *I bend*, means a bending towards. The word is used metaphorically to mean a desire or affection of the mind.

La Place—was a distinguished French mathematician and astronomer. He was born in 1749, and died in 1827. His great work is called *Mécanique Celeste*, which takes rank with Newton's *Principia*.

Meridian—from Medius, *the middle*, and Dies, *a day*, means in geography, a great circle passing through the poles of the earth. Each meridian is said to be the meridian of the place through which it passes.

Oscillation—from a Latin or Greek word signifying to *move*, is a movement backwards and forwards as we see in the pendulum of a clock when moving.

Oblate Spheroid—literally, *a flattened body, something in the shape of a sphere*. If the earth were a perfect sphere, both its diameters, so to speak, would be equal, but as it is "an oblate spheroid" the Polar diameter is 7,898 miles, while the Equatorial is 7,924.

Oval—from Ovum, *an egg*, having the shape of an egg, or rather of the cutting of an egg the long way.

Parallel—from two Greek words meaning *alongside of each other*, as applied to lines, for instance, are such "as are in the same plane, and which being produced ever so far both ways do not meet."

Pendulum—from Pendeo, *I hang*, is technically defined as a vibrating body suspended from a fixed point. Every boy has seen the pendulum of a clock.

Perpendicular—from Per, *through*, and Pendeo, *I hang*, is a line hanging straight down, as a plumb-line does, or as a pendulum of a clock when at rest.

Project—from Pro, *forward*, and Jectus, *thrown*, is to throw forward, and hence to scheme or contrive.

Sphere—is a Greek word corresponding

to the Latin word Globe or our word Ball. The earth is learnedly called "a terrestrial ball."

Velocity—from Velox, *swift*, speed or swiftness. Light travels at a velocity or at a rate of 200,000 miles a second.

Vibration—from Vibro, *I shake*, means a moving to and fro with a swift, tremulous motion.

LESSON IV. (p. 41.)

Abrupt—from Ab, *from*, and Ruptus, *torn*, is something torn off something else.

Adjacent—from Ad, *to*, and Jaceo, *I lie*, means lying near. Greenwich is *adjacent* to London.

Archipelago—means a sea interspersed with many islands. The name was originally given to the group of islands in the Ægean Sea, but it now means a group of islands anywhere. We speak of the Eastern Archipelago, the Indian Archipelago, &c.

Articulated—from Artus, *a joint*, means jointed, held together by joints.

Atmosphere—from two Greek words signifying *vapour* and *sphere*, properly means the vapour or air that surrounds our globe or sphere.

Australasia—from Australis, *southern*, and Asia, the name of one of the continents, would mean, etymologically, the land at the south of Asia, but in use the name is confined to one particular island.

Compact — from Con, *together*, and Pactus, *driven*, means what is firmly united. A compact town is the opposite of a straggling town. As a noun, Compact means a bargain—what is made fast between two parties.

Connected—from Con, and Nectus, *tied*, what is tied to something else.

Continent—from Con, *together*, and Tenens, *holding*, means "land holding together" in large masses.

Convulsion—from Con, *together*, and Vulsus, *torn*, means a tearing or rending asunder.

Exhibit—from Ex, *out*, and Habeo, *I hold*, is *to hold forth*, to show.

Equator—from Equus, *equal*, is the line that surrounds the earth and divides it into two equal parts.

Fragment—from Fractus, *broken*, is a piece broken from a large body.

Indented—from Dens, Dentis, *a tooth*. Land is said to be indented when it presents such an appearance as a child makes in its cake by biting out pieces.

Inspection—from In, *into*, and Spectus, *looked*, means a looking into any matter. *Inspector* is one who looks into the matter.

Normal—from a Greek word signifying *a rule*, is another word for *regular*. "Abnormal" corresponds with "irregular." "Normal type" is equivalent to "regular form."

Penetrate—from Penetro, *I bore*, is, literally, to bore through as a gimlet bores through wood, but metaphorically, *to find out*.

Polynesia—from two Greek words signifying *many* and *islands*, is a general name given to the islands that lie in the Pacific.

Protrude — from Pro, *forward*, and Trudo, *I thrust*, means to push out or forward.

Sections—from Sectus, *cut*, means a cutting or part of anything.

Terrestrial — from Terra, *the earth*, means of or belonging to the earth. A *terrestrial* globe represents the appearance of the earth; a *celestial*, that of the heavens.

LESSON V. (p. 46.)

A Rhombus—is defined as being a "four-sided figure, whose sides are equal and the opposite sides parallel but the angles unequal, two of the angles being obtuse and two acute."

Arctic—from the Greek word signifying *a bear*. The name was first applied to a constellation in the north, and hence it comes to mean *northern*. The Arctic and Antarctic seas are the seas that surround the north and south poles.

Atoll or *Atollon*—a name given by the natives of the Maldives to coral islands consisting of a strip or ring of coral surrounding a central lagoon. In geography it is applied to all coral islands enclosing a lagoon.

Cape Matapan—is the southern extremity of Greece. The word signifies *forehead*.

Columbus—the discoverer of America, was born A.D. 1435, and died May 20, 1506. Washington Irving, the celebrated American author, has written the best life of Columbus.

Commerce—from Commutatio, *change*, and Merx, Mercis, *merchandise*, is the change of commodities between two different nations, or, as M'Culloch defines it, "the exchange of commodities for commodities."

Comprehend—from Con and Prehendo, *I seize* or *hold*, means to take hold of anything, and metaphorically, *to understand*.

Contour—a French word signifying *outline*.

Civilization—from Civis, *a citizen*, includes everything that distinguishes the man of *cities* from the man of the *woods*. Civilization has been defined as "the state of being refined in manners, from the grossness of savage life, and improved in arts and learning."

Detached—from a French word signifying *to untie*.

Enormous—from a Greek word signifying *rule*, means *out of all rule*, and hence very large.

Hindostan—the country of the Hindoos, the original inhabitants of India. The country is now under British rule. The termination *stan* means country, as we see in Belochistan, the country of the Belochees; Afghanistan, the country of the Afghans.

Lagoon—is a Spanish word connected with our word Lake. In use it means a fen, marsh, moor, shallow pond.

Mediterranean—from Medius, *middle*, and Terra, *the land*, because the sea to which it is applied runs up into the land and washes the shores of three continents.

Steppes—A Russian word signifying large uncultivated deserts. They afford pasturage for herds of cattle.

Scandinavia—is the ancient name of Norway and Sweden, and these two countries together constitute the Scandinavian peninsula.

Vertical—from Vertex, verticis, *the top*, means the topmost part of a thing—an angle, for instance.

LESSON VI. (p. 56.)

Average—the derivation of the word is very uncertain, but its meaning is not of difficult comprehension. If a person gets *three* shillings one day, *five* another, and *one* a third, and *six* a fourth, his average income for these four days is *three shillings and ninepence*. This is a simple question in arithmetic.

Character—from a Greek word signifying *a mark*, is what distinguishes one person or thing from another.

Configuration—from Con and Figura, means the shape or formation of anything.

Correspond—from Con and Respondeo, *I answer*. When one thing fits another in any way it is said to correspond to it. When an event does not turn out as we expected it would, it is said "not to correspond with or to our expectations."

Diverge—from Di, *asunder*, and Vergo, *I tend*, means to go *asunder* or apart from the same point. *Converge*, is to come together to a point from different directions.

Indicate—from In and Dico, *I declare*, is to point out a thing.

Isolated—or insulated, means cut off from surrounding objects, and hence solitary or alone.

Intervene—from Inter, *between*, and Venio, *I come*, means to come between—referring either to time or position.

Limit—from the Latin Limes, limitis, *a boundary*.

Pelagic—from a Greek word signifying *the sea*, means of or belonging to the sea; oceanic.

Salient—and re-entering angles. *Salient* is from Salio, *I leap*. A salient angle is one that projects outwards from a figure; a re-entering one goes inwards and forms an indentation in the figure.

Tropics—from a Greek word signifying *to turn*, points in the apparent path of the sun at which, when he arrives, he seems to turn or bend his course.

Volcanic—of or belonging to Vulcan the God of Fire. Vulcan was supposed to cause the eruptions of Mount Ætna, and all sorts of actions in burning mountains get the name of volcanic action.

LESSON VII. (p. 58.)

Acuteness—from Acus, *a needle*, refers generally to cleverness, and is equivalent to ingenuity.

Aperture—from Aperio, *I open*, means an opening. If a cannon-ball go through a door, it will make an *aperture* in it.

Apprentice—from a French word signifying *to learn*, one who is put under a master to learn a trade.

Beneficial—from Bene, *well*, and Facio, *I do*, means *well-doing*—conferring a service on any person.

Britain's Oak—is put by a figure of speech for British ships, the thing out of which they are built being put for the thing itself. In the same way a part is often put for the whole: thus *sail* is used for a ship, and *hands* for men. A captain writing home said, "He had one of his *hands* shot through the *nose*."

Cancel—from Cancello, *I deface* or *erase;* hence, to annul or destroy.

Development—from a French word signifying an unfolding, and hence, growth or enlargement.

Energy—from a Greek word signifying *work*, means earnestness or zeal.

Haberdasher—a dealer in wares of various kinds; a country shopkeeper who sells anything wanted, but particularly linens, woollens, &c. Some say that the Flemings used to say to passers by, "Haber das hier,"—*Will you buy or have this, Sir?* and hence the name.

Heroic—from a Greek word, means of or belonging to heroes. These were celebrated in Greek poetry and tradition for wisdom, strength, and courage, and were regarded as a class intermediate between men and gods.

Humanity—from the Latin word Homo, *a man*, as being the highest and best attribute of man, *kindness*, particularly to other men under suffering, or to the lower animals. Distinguish between *human* and *humane*.

Indenture—means the mutual contract between master and apprentice, by which the master becomes bound to teach the apprentice and the apprentice to serve the master.

Luxuriance—from Lux, *light*, because light causes plants to grow fast and to a great size, means strong and vigorous growth.

Monotonous—from Greek words signifying *one sound;* and because one sound constantly repeated—"harping on one string," as we sometimes call it—is *wearisome*, the word comes to mean what is tiresome in general.

Operation—from Opera, *a work*, means the process of carrying on any work, or the work itself. To *co-operate* with a person is to help him at the same work.

Perspicuity—from *perspicuous*, clear, what can be seen through, means clearness.

Select—from Se, *aside*, and Lectus, *chosen*, what is set aside as peculiarly valuable.

Squadron—from an Italian word signifying *a square*, means generally a detachment of ships of war employed on a particular expedition.

Utility—the abstract *noun* from Utilis, *useful*, means usefulness.

LESSON VIII. (p. 64.)

Antiscorbutic—is a hybrid word coming from the Greek Anti, *against*, and the Latin Scorbutus, the *scurvy*, counteracting the scurvy. Lemon-juice is a great *antiscorbutic*.

Averted—from A, *from*, and Verto, *I turn*, means turned away. Aversion is from the same root, and means, metaphorically, *dislike*.

Byron (Commodore)—left England on his voyage round the globe June 21, 1764, and returned May 9, 1766. He discovered several islands in the Pacific, one of which still bears his name.

Canoe—is said to be a word of Indian (North American) origin, and it means a boat cut out of the trunk of a tree and impelled by a paddle. It is used in the rudest states of society.

Cape Horn—so called after a Dutch captain of the name of Hoorn. The name *Horn* was readily adopted because in the maps S. America tapers to a point something like a *horn*.

Compelled—from Con and Pello, *I drive*, forced or obliged to do anything.

Desolate—from Solus, *alone*, left alone, abandoned. A "desolate island" is one without inhabitants.

Disappoint—"A point, *punctum*, is the centre or fixing spot, at which, by means of a sharp instrument, anything is held to its place. Ap is ad—*to*. Dis means separation, division, partition, and so expresses the negation of what is positive in the word to which it is affixed; like the sign minus − in algebraic notation. To disappoint is, therefore, to unfix that which had been fastened to its place." —ISAAC TAYLOR.

Elucidation—from Lux, *light*, is the act or process of throwing light upon anything.

Equip, from Equus, *a horse*, is, literally, to make ready a horse, but it now means to make ready in general, so that we speak of *equipping* a ship for sea.

Impunity—from Pœna, *punishment*, means freedom from punishment. To say a person did something *with impunity* is equivalent to saying that he *was not punished* for doing the thing.

Journal—from the French Jour, *a day*, is a daily account of what is done. Journey is the travel of a day. Journeyman, one who works by the day.

Launch—is defined by Crabb as being "a particular kind of boat which is very useful in under-running the cables of different ships that are fastened across each other."

Negative—here used as the opposite of *positive*, denotes the absence of a thing. It is sometimes said that it is impossible to prove a negative; but surely when Cook sailed over certain seas, and found no land, he may be said to have proved that there was none.

Pinnace—is defined by Crabb as being "a small vessel with a square stern, going with sails and oars, and carrying three masts; this is chiefly used for conveying."

Positive—means real, existing in fact. If any one assert that there are men with tails let him show us one, and that will be a *positive* proof of the correctness of his opinion.

Sepulchre—from Sepultum, *to bury*, is a place of burial. Used in poetry, perhaps, more than in prose:—

> "And every turf beneath their feet
> Shall be a soldier's sepulchre."
> CAMPBELL.

Vinegar—from the French Vin, *wine*, and Aigre, *sharp* or *sour*, an acid liquor got from wine and various other liquids.

Wallis—set sail from England on his voyage round the world July 26, 1766, and returned May 20, 1768, a period of less than two years.

LESSON IX. (p. 70.)

Gallant—probably from Gallus, *a cock*, means one of noble bearing. "A gallant soldier means one that faces the enemy boldly."

Pall—from Pallium, *a cloak*, originally worn by Roman emperors, now means the cloth thrown over a coffin or dead body at funerals.

Profane—from Pro, *before*, and Fanum, *a temple*, means what was not sacred enough to be admitted into the temple, hence, what is "common and unclean."

Serene—from the Latin Serenus, *calm, clear, without a cloud*, probably from a Greek word signifying peace. Serene is, therefore, untroubled and calm.

Tomb—from Tumulus, *a hillock*, has reference to the rising that is generally made above a grave. It often means a monument to protect the remains of the dead.

Triumph—is a word in use among the Romans to signify a magnificent procession and solemnity decreed by the senate to a victorious general for having conquered a province or gained some signal victory.

Vulgar—from Vulgus, *the common people*; what is characteristic of the mass of the people, hence, low, bad, &c.

GEOLOGY.

LESSON I. (p. 72.)

Animals—from Anima, *life*, are beings endowed with sensation and voluntary motion.

Antimony—is "a metallic, solid, heavy, brittle substance, probably so called from Greek words signifying *against* and *alone*, *i. e.*, an enemy to solitude, because it is very seldom found pure, but mostly mixed with other metals." —CRABB.

Carbon—from Carbo, *a coal*, is defined as being "a simple body, black, brittle, light, and inodorous."

Charcoal—is coal made by *charring* or burning wood, hence, the substance of wood half burned.

Classification—from Classis, *a form*, is the act of reducing things to order. Suppose there are 100 books on the table: I might *classify* them in various ways—(1) as to their size; (2) as to the subjects they treated of; (3) as to the languages they are written in; and (4) many other ways.

Compacted—from Con and Pactus, *driven*, what is driven closely together so as to occupy little room.

Elements—are the first principles out of which various bodies are made. The ancients thought that *fire, air, earth*, and *water*, were the elements out of which everything was composed. This is now known to be a mistake.

Extract—from Ex, *out*, and Tractus, *drawn*, whatever is taken out of anything else. A passage from a book is called an *extract*.

Granite—probably from the word *grain*, because the stone so called seems to be made up of *grains*. London Bridge is built of *granite*.

Ingredients—from In and Gradior, *I go*, what enters into the composition of any body.

Iodine—from a Greek word signifying *to resemble a violet*. The iodine of commerce is mostly got from kelp, or sea-weed.

Lithology—from the Greek word signifying *a stone*, is the science of stones and rocks.

Minerals—from a low Latin word, Minera, *a vein of metal*, is the name of the hard component parts of the earth, such as salt, fossils, ores, earth, &c.

Oxygen—hydrogen, and nitrogen. The termination of these words is from a Greek word signifying *to produce*, and the first part of the words means respectively *acid*, *water*, and *nitre*. Oxygen is the great supporter of animal life, nitrogen destroys it.

Phosphorus—from two Greek words signifying *light* and *bearer*, was a name originally applied to the Morning star. It now means a chemical substance, flesh-coloured or yellowish, luminous in the common temperature of the air. Lucifer matches are tipped with phosphorus.

Science—is, literally, *knowledge*, but it means more than that now. "Science is the knowledge of many, orderly and methodically digested and arranged, so as to become attainable by one."—Herschel.

Statuary Marble—Marble, from a Greek word signifying *to shine*; statuary; what is used in making statues.

Transparent—from Trans, *through*, and Pareo, *I appear*, means "whatever can be seen through." Glass is transparent, so is pure water. A brick is opaque.

Vegetables—from Vigeo, *I grow*, is a name applied to everything that grows in the earth, such as grass, shrubs, trees, &c., &c.

LESSON II. (p. 78.)

Alabaster—comes from two Greek words signifying *what cannot be taken hold of*, and the substance was so called from its smoothness.

Alumina—means the base of *alum*. The base is called aluminum and the substance itself alumina. Another name for alumina is *argil*, or argillaceous earth.

Asbestos—from two Greek words signifying *what cannot be extinguished*, is a sort of mineral substance that has been woven into cloth and used to be wrapped around dead bodies.

Brilliant—from the French Briller, *to shine or sparkle*, signifies sparkling with lustre.

Crevice—from the French Crever, *to burst or split*, means a cleft or fissure. We speak of the "crevice" of a rock.

Crystal—is a kind of glass or precious stone, frozen, as it was thought, into that bright substance. The word comes from a Greek word signifying *frost*.

Diamond—from the Greek word signifying *a hard stone*, is the name given to a mineral remarkable for its hardness.

Effulgent—from E, *out*, and Fulgeo, *I shine*, means bright, brilliant, or shining.

Glauber Salt—Glauber was a physician of Amsterdam, who died in 1668. He discovered the purgative salt that still bears his name.

Glucina—is a white powder without taste or smell, and insoluble in water. The salts of glucina are sweet, hence its name (from a Greek word signifying *sweet*). The base of glucina is called glucinum.

Igneous—from Ignis, *fire*. An *igneous rock* is one that has been formed by the effects of fire.

Meerschaum—comes from two German words signifying *sea-foam*, a substance that is found on the shores of the Baltic Sea. When dried it becomes hard, and is then formed mostly into tobacco-pipes.

Precious—from Prex, precis, *the price of a thing*, what you have paid a great price for, and hence, what is valuable.

Silica—is a word coming from the Latin Silex, *flint*, and it constitutes the characteristic ingredient of a great variety of minerals. It is the chief substance out of which glass is made.

LESSON III. (p. 86.)

Ceres—the ancient goddess of corn, is frequently put for corn or corn-fields.

Combined—from Con, *together*, and Bini, *two by two*, would, literally, mean two sorts of things united, but practically, it means any number of things united together.

Fossil—from Fossus, *dug*, means, literally, anything dug. The term is now confined to organic remains.

Inhume—from In and Humus, *the ground*, is to put into the ground or to cover with earth. To *exhume* is to dig out of the earth.

Meteor—from a Greek word signifying *lofty*, was a name originally applied to *fire-balls* and other appearances in the atmosphere. Meteorology, or the science of meteors, now includes a great deal more than the phenomena of the atmosphere.

Occur—from Ob, *in the way of*, and Curro, *I run*, means to take place, to happen, or to be found.

Petrify—is a hybrid word coming from the Greek word signifying a rock or stone, and the Latin termination *fy*, to make. "To petrify" is, therefore, to turn shells, fish, wood, &c., into stone.

Platina—or more generally Platinum, gets its name from the Spanish word Plata, *silver*, and is a white sort of metal, exceedingly ductile, but very difficult of fusion. It is the rarest and dearest of all the metals.

Prow—from the Greek and Latin word Prora, *the fore-part of a vessel*. In this lesson prow is put by a figure of speech for vessel—a part for the whole. The figure is called Synecdoche. The poet Thomson uses the word "prow" in the same sense;—

> "Such was the Briton's fate
> As with first *prow*, (what have not Britons dared!)
> He for the passage sought, attempted since
> So much in vain," &c.

Restricted—from Re and Strictus, *drawn*, means *drawn back or in*, hence, narrow or limited.

LESSON IV. (p. 90.)

Agriculture—from Ager, *a field*, and Cultus, *a tilling*, would mean the tilling of fields.

British Museum—(the) was founded in 1753 by the purchase of Sir Hans Sloane's library and vast collection of the productions of nature and art. It is now the grand national repository for objects of antiquity, for MSS., sculptures, &c., &c.

Colossal—is the adjective from Colossus, which both in Greek and Latin means a statue of gigantic size. The most celebrated colossus of antiquity was one at Rhodes, a statue of Apollo, so high that ships could sail under its legs. Their ships were not equal to ours, be it understood.

Concretions—from Con and Cretus, *grown*, the process by which soft or fluid bodies become thick or hard. Metallic matter *concretes* or *indurates* into a solid body.

Corroded—from Con and Rodo, *I gnaw*, means eaten away as if by rust.

Depend—from De and Pendeo, *I hang*, to hang from, as a chandelier from a beam in the roof, and hence, *to spring from as a cause*.

Domestic—from Domus, *a house*, of or belonging to a house. "A domestic convenience" is something that facilitates the work or increases the comfort of a house or family.

Indestructible—is compounded of three words:—Structible (if there were such a word) would mean "able to be built;" destructible, "able to be unbuilt," that is, destroyed; *In* signifies not. The whole word, then, means "not able to be destroyed."

Macadam—introduced an improved system of road making, and it now goes by his name. Many of the streets of London are *macadamised*. Mr. Macadam was born in the south of Scotland in 1756, and died in 1830.

Opaque—from the Latin Opacus, *not pervious to the rays of light*, not transparent. Glass is transparent. A piece of wood is opaque.

Precipitation—from Præ, *forward*, and Caput, *the head*, is the process by which any body separates from others in a solution, and falls (headlong) to the bottom.

Predominates—from Præ, and Dominus, *a master*, means to come the master over one, that is, to rule, or bear the sway.

VEGETABLE PHYSIOLOGY.

(p. 99.)

Agency—from Ago, *I do*, means the conduct or management of other people's affairs, and the person who does manage them is called an *Agent*.

Arsenic—from a Greek word signifying *strong*, is a metal or mineral substance, soft, brittle, and highly poisonous.

Caoutchouc—is the juice of several plants. It principally comes from South America. It is much used for making water-proof clothing.

Combustion—from Con and Ustus, *burned*, the letter *b* being interposed for the sake of the sound. Combustion is the process of burning.

Conspicuous—from Con and Specio, *I look*, is "what can be seen by all," eminent, remarkable, bright, &c.

Consume—from Con and Sume, *I take*, means to *take away altogether*. Rust consumes iron, fire consumes wood, &c.

Contact—from Con and Tactus, *touched*, means the act of touching. We speak of two things being in contact when they touch each other.

Cuticle—from Cutis, *the skin*, is, literally, the little skin or outside skin.

Derived—from De and Rivus, *a river*, means *springing from*, deduced from, as the river is from its springs in the mountains.

Endogenous—from two Greek words signifying *within* and *I grow*, is a name applied to certain plants whose stems grow by successive additions to the inside.

Examine—from the Latin Examen, *the tongue of a balance*, means to weigh carefully, to look attentively at a thing so as to know its nature, worth, &c.

Excrement, from Excretus, *separated*, is the name applied to the substance rejected by an animal as useless.

Exogenous—from two Greek words signifying *out* and *I grow*, is a name given to those plants which add to their wood by successive external additions.

Fissile—from Findo, *to split*. That may be split, cleft, or divided in the direction of the grain, or of natural joints.

> "This crystal is a pellucid fissile stone."
> Newton.

Graphite—from the Greek word signifying *to write*, is a name applied to black-lead because it is used for writing with.

Gutta Pertsha—or Gutta Percha, is the produce of a large forest-tree growing in the mountains of Singapore and in Borneo. It was first made known in England in 1843, but it is now extensively used in the arts.

Guano—is a substance found on certain islands in the South Seas, which are the resort of large flocks of birds, and chiefly composed of their excrement. It is used as manure.

Microscope—from two Greek words signifying *small* and *I look*, is an optical instrument which magnifies objects so as to let us see parts, which from their minuteness, the naked eye could not see.

Myriad—from the Greek word signifying *ten thousand*, often used indefinitely for a large number.

Prominent—from Pro, *forward*, and Mineo, *I hang*, what hangs forward, and so attracts attention.

Pseud-organic—The word organic we have already explained. The prefix is from the Greek, and means *not real*. A prophet is one who foretells events; a pseudo-prophet would be one who merely pretended to do so.

Reptile—from the Latin Repo, *I creep*, is the name of a class of cold-blooded animals.

Rhubarb—is the root of a plant cultivated mostly in China. It is used in medicine.

Stellate—from Stella, *a star*, shaped like a star, *i. e.*, round, with rays branching out from the centre.

Succulent—from Succus, *juice*, is full of juice or sap.

Supplement—from Sub and Pletus, *filled*, is an addition to a thing so as to make it more complete. Appendix and supplement are often used in the same sense.

Volatile—from Volo, *I fly*, what readily flies off. Ammonia is said to be volatile because it sends off odoriferous particles.

ANIMAL PHYSIOLOGY.

(p. 137.)

Abyss—from two Greek words signifying *without* and *bottom*, means "what is without bottom," and therefore fathomless. Milton speaks of

> "The dark unfounded bottomless abyss."

Artery—from two Greek words signifying a *pipe* or *passage*, and *breath* or *air*, was a name applied to certain vessels by the ancient anatomists because they are usually found filled with air, *i. e.*, empty in the dead body. The arteries convey the blood *from* the heart; the veins *to* the heart.

Capacity—from Capio, *I take*, signifies both what one is able to do and what any thing is able to contain. We speak of a person of good capacity, and of a basin of large capacity.

Cartilage—(probably) from Caro, Carnis, *flesh*, is an elastic substance intermediate between bone and ligament. It is commonly called *gristle*.

Dilate—from Di, *asunder*, and Latus, *carried*, means to blow out or expand. If you blow wind into a bladder it will dilate. In breathing, the chest alternately *dilates* and contracts.

Discern—from Dis and Cerno, *I separate* or *perceive*, means to see clearly, and as applied to the mind to distinguish its perceptions accurately. The noun is *discernment*.

Evidence—from E, *out*, and Video, *I see*, means *full proof* of any thing. *Evidence* is somewhat stronger than *proof;* it makes the proof evident, as it were, and undeniable.

Exquisite — from Ex and Quisitus, *sought out*, what has been sought out from other things with great care, and hence, what is the best of its kind.

Foliage — from Folium, a *leaf*, is a general name for the leaves of a tree, in the same way as the word flock includes all the sheep of which it is composed.

Gorgeous — comes from the verb to gorge, to feed gluttonously, and transferred from the palate to the eye, it means splendid, magnificent.

Masticate — from a low Latin word Masticare, signifies to bruise and crush the food with the teeth. The process is called *mastication*.

Miniature—from Minus, *less*, means a reduced copy of a thing. The second *t* is a miniature of the first (T T).

Pliant—from Plico, *I bend*, what is easily bent, and hence, easily persuaded to do anything.

Privilege—was a word used in the Roman law, and meant any measure brought into the senate for the benefit of an individual. It means now an exception from a law in favour of an individual or body. Sir James Mackintosh defines the word thus:—"*Privilege*, in Roman jurisprudence, means the exception of one individual from the operation of a law."

Saliva—is the fluid secreted from the mouth by certain vessels called the salivary glands. Its use is to keep the mouth moist, and to mix with the food, when we are chewing it.

Saunter—from the French Sainte terre, the Holy Land. After people purposed to go to the Crusades, that is, to the Holy Land, they used to dawdle about, and hence the word came to signify *dawdling* and going about doing nothing.

Sedate—from Sedatus, *made to sit*, and hence quiet, tranquil, serious. *Composed* relates more to the outward appearance; *sedate* to determination of purpose.

Skeleton—from a Greek word signifying *I dry or make dry*, is the name given to the dried framework of an animal body.

Serried—from a Spanish word signifying a *saw*, means formed like the edge of a saw.

Unblemished—having no blame or cause of blame attached to it, hence, pure, without spot or stain.

Vibration—from Vibrate, *to brandish or shake*, is generally used to signify a sort of tremulous motion.

Veins—from the Latin Vena, means the elastic tubes which convey the blood back to the heart after it has been all over the body. See *Artery* in this lesson.

ETHNOLOGY.

(p. 157.)

Anatomist—from two Greek words signifying *up* and *I cut*, is one who cuts up or (using a word of Latin derivation) dissects the human body. The anatomy of other animals is called *comparative anatomy*.

Ancestors—from Ante, *before*, and Cedo, *I go*, are those who go before us. *Progenitors*, or *forefathers*, is used in much the same sense. Those who come after us are our descendants or posterity. Those who live along with us are our contemporaries.

Autumn—is said to be derived from Auctum, *to increase*, and Omnia, *all things*, because that is the season of the year when all things yield their increase.

Approximation—from Ap for Ad, *to*, and Proximus, *nearest* or *next*, is the process of coming near to a thing without absolutely reaching it.

Comparison—from Con and Par, *equal*, is the process of laying two things together, as it were, and seeing how far they are equal. The name is often applied to the faculty of the mind by which the process is carried on as well as to the process itself.

Cornwall—was originally called *Kernou*, a term probably connected with the Latin Cornu, *a horn*, in allusion to its numerous promontories and projecting points.

Dispense—from Dis, and Pensus, *paid*, means *to pay off*, that is, to do without a person or thing.

Encampment—is the process of taking up a station in the field, from the French and Latin Campus, *a field*.

Equator—is the line that goes round the earth and divides it into two equal parts. Equatorial is the adjective derived from it.

Ethnology—from two Greek words signifying *a nation* and *discourse*, is the science that treats of the peculiarities of tribes of people or nations, denoting their physical and moral characteristics, customs, manners, &c. It is sometimes called Ethnography, and used to be embraced in books on geography. It has now risen to the dignity of a separate science.

Exaggerate—from Ex and Agger, *a heap*, is to make a heap out of little, or, as we say, a mountain out of a mole-hill.

Extinct—from Ex and Stinctus, *put out*, means deprived of life, or referring to flame *put out*. The noun derived from it is Extinction.

Fragment—from Frango, *I break*, is a piece broken off from a large body. When we say that a thing is broken into fragments we mean that it is broken into small pieces.

Gipsy—or Gypsy, is the name given to a well-known race of vagrants. It is supposed to be a corruption of the word Egyptian, because, when they first appeared in Western Europe, they were under a leader, who styled himself the Duke of Lower Egypt. The French call them Bohemians, and, in fact, every nation has a different name for them. Fortune-telling and thieving are their predominant occupations; but the schoolmaster and the policeman press hard on them in our day.

Hamlet—is the diminutive of the Saxon word Ham, *i. e.*, home. A *hamlet* is a place where people assemble or meet together, whether house or village.

Identical—from Idem, *the same*, means the very same. To *identify* a person is to prove him to be the same person (for instance) as did something before.

Investigate—from Vestigium, *a footstep*, is *to trace out* by following the footsteps of another, and hence, to search or inquire after. The *investigation* of truth is the proper business of man.

Migration—from Migro, *I remove*, is the act of moving from one place to another. When people leave this country to settle in another, we call them *E*migrants, and the people of the country where they settle call them *Im*migrants.

Museum—from Musa, the Goddess of Study, is a place dedicated to study—or a collection of objects of nature and art. The name is said to have been first given to that part of the palace where Ptolemy placed the famous Alexandrian Library.

Parasite—from two Greek words signifying *at hand* and *food*, originally meant one who collected the corn allotted for public sacrifices. It now means one who lives on another or flatters him for the sake of self-interest.

Periodical—from two Greek words signifying *about* and *a way*, what happens at regular intervals. As a noun, it means a publication appearing at intervals—a week, month, &c.

Phalanx—was a name originally applied to the battle array of the Macedonians, formed into squares of fifty men abreast and sixteen deep. Hence, any body of men or (metaphorically) birds arranged in complete order.

Propensity—from Propensus, *hanging down*, means a tendency or inclination to a thing. *Propension* and *propensness* are used by old writers in the same sense.

Psychology—from the Greek words signifying *life, or the soul*, and *discourse*, means what is otherwise called "mental philosophy." The adjective is Psychological.

Rail—or Water-rail, is the name of a bird classed among the "long-toed waders."

Quadruped—from Quatuor, *four*, and Pes, pedis, *a foot*, means a four-footed animal. A mouse and an elephant are equally quadrupeds. Man is a *biped*, or two-footed animal.

Soldier—from Soldarius (a low Latin word for a coin), is one "who serves for pay:"

> "And every turf beneath their feet
> Shall be a *soldier's* sepulchre"
> CAMPBELL.

Turban—is the usual head-dress of the Turks, Persians, and most other Eastern nations. It differs in form in different nations and in different classes of the same nation.

Zone—from the Greek word signifying a *belt* or *girdle*, is the portion of the earth's surface included between two parallel circles. There are five zones, but they are too well known to require description here.

Zoologist—from two Greek words signifying *an animal* and *discourse*, means any one who knows the nature and classification of animals.

In use the term *Zoology* is restricted to the science of the outward characters, habits, properties, and classification of animals.

NATURAL HISTORY.

LESSONS I. AND II. (p. 166.)

Adult—from Ad and Ultus, *grown*, is a person grown to full size and strength, and who has come to the years of manhood.

Amiable—from Amo, *I love*, and the termination *able*, able to be loved, and hence, attracting love and regard.

Attribute—from Ad and Tribuo, *I bestow* or *give*, means "to consider as belonging to." We *attribute* nothing to God that contains a contradiction."—TILLOTSON. The word is used also as a noun in the sense of *characteristic* or *quality*.

Authenticate—connected probably with the word Author, means to trace back to its proper author, and show that the thing is what it pretends to be. To prove the *authenticity* of the Gospel of St. John, for instance, you must prove that St. John really wrote it. To prove the *genuineness* of the text which we have, you must trace it back to the time of the author, and prove that it is such as he left it.

Collateral—from Con and Latus, lateris, *a side*, refers to something that lies *side by side* with another subject, and yet is different from it, hence, connected and conjoined.

Candid—from Candidus, *white*; hence, pure, sincere, ingenuous, and openhearted.

Definition—from De and Finis, an *end* or *boundary*, is such a description of a thing as shall point it out from other things that more or less resemble it.

Discussion — from Dis and Cussus, *shaken*, means such a shaking of a subject as shall thoroughly explore it. It is generally used in a metaphorical sense; thus Dr. G. Campbell says, "Free and fair *discussion* will ever be found the firmest friend to truth."

Emanate—from E, and Mano, *I flow*, is to *flow out of*; thus we say, Light *emanates* from the sun. *Emanation* is the corresponding noun.

Embryo—from a Greek word signifying *to shoot*, refers primarily to the buds of flowers, &c., but secondarily to the rudimentary forms of animals, fishes, birds.

> "Kind nature the embryo blossom will save."
> BEATTIE.

Entomology—from two Greek words meaning *an insect* and *discourse*, is the science of insects. The word *insect* is the exact equivalent for the Greek word, which means *cut into*.

Fiat—is a Latin word signifying "Let it be." Light was created by the *Fiat* of the Almighty, that is, "God said, *Let there be* light, and there was light."

Hypothesis—from Greek words signifying *under* and *I place*, is a supposition formed or taken for granted to account for certain phenomena. The word has so many meanings that it is impossible to explain them all here. *Hypotheses* must not contradict *facts*, or they are of no value.

Impel and *Impulse*—from In and Pello, *I drive*, Pulsus, *driven*, means to drive in or to do anything without an ulterior motive. If I strike a nail it goes into the wood by the *impulse* of the hammer, but the word is applied secondarily to mean an influence on the mind.

Instinct — from the Latin word Instinctus, *excited*, *driven on*, is used both as an adjective and a noun. As an adjective it means *urged* or *impelled*, and as a noun, "that which incites or urges on." A satisfactory definition of *instinct* is still wanted. Dr. Beattie defines it as "A natural impulse to certain actions which the animal performs without deliberation, without having any end in view, and frequently without knowing what it does." After reading carefully what is said on the subject in the text the scholar will hardly accept this definition as absolutely correct, though it is not far from the truth.

Logic—from the Greek for a *word*, means the science and the art of reasoning. A *logical* inference is a sound one, and such as will stand examination.

Metaphysical—is a word that, from accidental causes, has come to signify something relating to the mind. *Physical science* treats of the properties of matter, metaphysical, of the operations of the mind. Some of the greatest metaphysicians of our country are Locke, Berkeley, Hobbes, Butler, Hume, Reid, Stewart, Brown, Mill, Hamilton, &c., &c.

"*Our fellow-mortals*"—is quoted from Burns' address "To a Mouse." The verse is worth giving in full:—

> "I'm truly sorry man's dominion
> Has broken nature's social union,
> And justifies that ill opinion
> Which makes thee startle
> At me, thy poor earth-born companion
> And fellow-mortal!"

"*Palpable obscure*"—is quoted from Milton, where, according to his usual practice, he makes the adjective "obscure" stand in place of a noun. "Palpable" is what may be felt. "Palpable obscure," then, is darkness so great that it can be felt.

Salmon—said to be derived from Saliendo, *by leaping*, from the leaps they make, is the name of a well-known fish that is found in our northern seas and rivers.

Senior—the comparative of Senex, *old*, means the elder. It is often opposed to Junior, *the younger;* thus, we speak of the father, as John Smith, Senior, and the son, as John Smith, Junior. To arrange people in the order of *seniority* is, in other words, to rank them according to age.

Stork—from the Greek word signifying *natural affection*, is a bird remarkable for affection to its young, and, as some say, to its parents. They abound in Holland.

Vertebra—is the Latin name of one of the bones which constitute the back bone or spinal column, hence, animals with a back-bone are called *vertebrate.*

Vigilant — from Vigilans, *watching*, means attentive, wide-awake. The noun is *vigilance.*

LESSONS III. and IV. (p. 181.)

Achieve—from the French Achever, *to bring to a head or end*, is to execute or do. Achievement is the corresponding noun.

Abstract ideas—are represented by abstract nouns, such as mercy, justice, roundness, &c. *Concrete* is the opposite term. The faculty by which we can conceive a quality apart from other qualities is called *abstraction.*

Agglutinate—from Gluten, *glue*, is *to stick together* or cause to adhere, as with glue or other viscous substances.

Albumen—is the Latin word for "the white of an egg," whence our word *albuminous*, having the properties of *albumen.*

Anecdote—from two Greek words signifying *not* and *published* or *given out*, originally meant secret history or facts not generally known. It now means a detached incident in biography, history, &c.

Carnivora—from Caro, carnis, *flesh*, and Voro, *I devour*, means flesh-devouring. The Carnivora are the second order of Cuvier's *feræ*, including those species of which the teeth are peculiarly adapted for destroying living prey, and for tearing, crushing, and dividing flesh.

Chameleon—is both the Greek and Latin name of an animal of the lizard tribe, remarkable for the power of changing its colour.

Comprise—from Con and Prehensus (French Compris) *taken*, to contain or hold. A great deal may be *comprised* in a few words.

Consummate—from Con and Summus, *the highest*, means finished and complete in all its parts, carried to the highest perfection possible.

Demarcation—is a hybrid word from the Latin De and the Saxon word Mark, and means the act of marking off or setting a limit to anything. It is not easy to draw the line of *demarcation* between liberty and licence.

Electively—*i. e.*, by way of choice or election.

Energies—from Greek words *within* and *work*, mean earnest works. To work with energy is to work from within, or, as we say, *from the heart.*

Fastidious—from Fastidio, *I disdain*, full of disdain, over-nice, difficult to please, &c.

Forage—is a word of uncertain derivation, but it means food of any kind for horses and cattle, as grass, hay, oats, &c.

Gregarious—from Grex, gregis, *a flock*, is a name applied to animals that herd together. Many species of birds are *gregarious*, but birds of prey are not so.

Hybernation—from Hybernus, *wintry*, is the act by, or the state in, which certain animals exist during *winter*, when they cease to perform their customary functions.

Inexplicable—from Plico, *I fold.* Explicable would mean "able to be explained or unfolded." Inexplicable is, therefore, "not able to be explained or accounted for."

Intercept — from Inter, *between*, and Ceptus, or Captus, *taken*, is to take or seize by the way. If a ship is sailing to any part and the enemy captures her, the provisions, &c., which she carried would be said to be *intercepted.*

Lichens—are plants of a very low organization which grow on the bark of trees or rocks. The word is of Greek derivation.

Orifice—probably from Os, oris, *the*

mouth, and Facio, *I make*, is the aperture of a pipe, tube, &c.

Pervade—from Per, *through*, and Vado, *I go*, is to penetrate and pass through the whole extent of a thing.

Provender—(from the French) means dried food of any kind, *provided beforehand* for the use of men, horses, cattle, &c.

Rigid—from Rigeo, *I am stiff*, means stiff, not easily bent. Rigidity is the abstract noun.

Stratagem—from the Greek word meaning "to lead an army," is any trick to deceive an enemy, and hence, a *deception* of any kind.

Torpid—(formed on the analogy of Rigid just given) from Torpeo, *I am benumbed*, what has lost power of sensation or motion.

Viscid—from Viscus, *bird's-lime*, hence, anything that oozes out, and is of a sticky nature, is called a "viscid secretion."

POLITICAL AND DOMESTIC ECONOMY.

(p. 197.)

Affluent—from Ad and Fluens, fluentis, *flowing*, means, as an adjective, rich, opulent, having things in abundance. *Superfluous* is *overflowing* or abounding to excess. The *confluence* of two rivers is where they meet and form one.

Alleviate—from Levis, *light*, is to lighten. Time *alleviates* grief.

Articulate—from Articulus, *a little joint*, is to utter or emit distinctly, disjoined and separate sounds.

Avarice—from Avarus, *greedy*, is the morbid excess or abuse of the desire of wealth—the desire of money for its own sake, and not for the good that it may do.

Bullion—is the name applied to uncoined gold or silver. It is probably connected in some way with the word *ball*, *i.e.*, mass or lump.

Companion—from Con and Panis, *bread*, is properly one who takes bread with another, and hence is on terms of intimacy with him.

Confiscate—from Con and Fiscus, *the royal treasury*, means to seize anything and put it (or its value in money) into the royal or common treasury.

Cowries—are small shells brought from the Maldives, which pass current as coin in smaller payments in India and Africa—100 of them being about equal to our penny.

Exempt—from Ex and Emptus, *bought*, is, literally, *bought out*, hence, freed from, released. Clergymen, physicians, &c., are exempt or exempted from the performance of certain duties that other people must perform.

Expedition—from Ex and Pes, pedis, *a foot*, a march or journey in which there must be nothing to entangle *the feet*; a body of men sent out by sea or land to explore new countries. Franklin's *expedition* to the Arctic Regions and Richardson's to the interior of Africa have both turned out unfavourably.

Extort—from Ex and Tortus, *twisted*, is to twist out of another man's hands, hence, to seize by force, and unjustly.

Indigent—from Indigeo, *I am in want*, means extremely poor.

Litigation—from Lis, litis, *strife*, means specially, a suit at law. A *litigious* person is one who is fond of going to law.

Misanthrope—comes from two Greek words signifying *hatred* and *man*, and means the same thing as our compound word *man-hater*. The feeling is called Misanthropy, and it is the opposite of Philanthropy.

Miser—is the Latin word signifying *miserable*, in general, but, in use, the word means one who denies himself the comforts of life when he could afford them, or, as Trench expresses it, "the man addicted to the vice of covetousness, and who loves his money with his whole heart and soul."

Portable—from Porto, *I carry*, what is able to be carried with ease.

Pristine—from Pristinus, *ancient*, *old*. We speak of man's pristine or primitive state of innocence.

Rapacious—from Rapio, *I seize*, given to plunder, or disposed to seize by force. Rapacity and rapine are corresponding nouns.

Salubrious—from Salus, salutis, *health*, and Fero, *I bring*, what causes or brings health. We speak about a *salubrious* climate in opposition to an unhealthy one.

Selected—from Se, *aside*, and Lectus, *gathered*, what is put aside as more valuable or worthy of preservation than the general stock.

Sympathy—from two Greek words signifying *together* and *suffering*, would literally mean the feeling we have with another's suffering, but it is used in the wider sense of a fellow-feeling of any sort. We sympathise with the joys as well as with the sorrows of our friends.

CHEMISTRY.

(p. 221.)

Alchemy—an imaginary art once much practised, but now merged in the study of chemistry. The root of the two words Chemistry and Alchemy is evidently the same—some say a Greek word signifying *to form*. *Al*, the Arabic article, corresponds to our *the*.

Analysis—from two Greek words signifying *to cut up*, is the separation of anything into the elements of which it consists. The word is differently defined in Logic, Grammar, Chemistry, Geometry, &c., but the etymological idea of separating into parts runs through all.

Antagonist—from two Greek words signifying *against* and a *wrestler*, means one who contends with another in combat; hence, an adversary of any kind. *Antagonistically* is the corresponding adverb.

Calico—is the name of a particular sort of cloth which originally came from Calicut, in India. Fabrics often get their name from the place whence they originally came—such as Cambric from Cambray, Nankeen from the city of Nankin in China. The word China itself is proof of the same thing. How?

Chemistry—a word of very obscure derivation; is the science that investigates the nature and properties of matter and their mutual actions and combinations.

Cohesion—from Con and Hæreo, *I stick*, means *a holding together*. It is differently used in the different sciences, but this idea runs through all.

Detected—from De, and Tectus, *covered*, means *uncovered*, found out. The word is generally applied to cases where there is a wish to conceal.

Divellent—from Di and Vello, *I pull*, means pulling asunder. In chemistry, the word is used in a peculiar sense, as will be seen in the text.

Effervescence—from Ex and Ferveo, *I boil*, is the name applied to the escape of gaseous matter from liquids, as in the act of fermentation. All liquids from which bubbles of gas rapidly escape, so as to resemble boiling, are said to effervesce. Every child has seen the two powders that go by the name of seidlitz powders mixed together in water and heard the boiling, hissing sound that ensues.

Explosion—from Ex and Plodo (Plaudo?), *I hiss*, means a sudden expansion of any elastic fluid with force and a loud report.

Evolve—from E and Volvo, *I roll*, means to *roll out* or develop. The corresponding noun is *evolution*.

Ignite—from Ignis, *a fire*, means to take fire. If you draw a lucifer match rapidly across sand-paper, it will *ignite*. The corresponding noun is *ignition*, which is defined as the act of setting fire to, or of taking fire; as opposed to combustion or burning, which is a consequence of ignition.

Nomenclature—means, literally, a *list of names*, but it now means the language peculiar to any art or science; thus, we speak of the nomenclature of Chemistry, Botany, &c.

Pneumatics—from a Greek word signifying *air* or *breath*, is that part of natural philosophy which treats of the mechanical properties of air. "A pneumatic trough" is a vessel in which gases are collected, retained, and properly managed.

Pulverization—from Pulvis, pulveris, *dust*, is the act of reducing any solid body to dust or powder.

Sanguine — from Sanguis, sanguinis, *blood*, literally, *abounding in blood*; secondarily, *cheerful*, *ardent*. A person of *sanguine* temperament sees everything in the best light. *Sanguinary* is from the same root, but is quite differently used. We speak of a "sanguinary battle" when many lives are lost.

Spermaceti—is the name applied to a substance that crystallizes spontaneously out of the oil of the whale that goes by the same name. This species of whale is mostly confined to the South Seas.

Synthesis—from two Greek words signifying *together* and *a placing*, is the opposite of *analysis*—explained above. If we analyse water, we find that it consists of certain elementary gases; if we put these gases together, w reproduce water. The former case is Analysis, the latter, Synthesis.

HOW TO OBSERVE.

(p. 245.)

Albion—is the ancient name of England, perhaps of the whole island of Great Britain. Many connect it with the Latin word Albus, *white*, and suppose that it received its name from the white (chalk) cliffs of Dover.

Apathy—from two Greek words signifying *without* and *suffering*, means total indifference. Milton opposes the word to *passion* in the well-known lines:—

> "Of good and evil much they argued then,
> Of happiness and final misery,
> Passion and *apathy*, and glory and shame,
> Vain wisdom all, and false philosophy."

Astronomer—from two Greek words signifying *a star* and a law or rule, is one who studies the motions of the heavenly bodies and the *rules* by which they are governed. The derivation given in the text is slightly different, and, if not so accurate, is more poetical.

Attention — from Ad and Tentus, *stretched*, is the name given by metaphysicians to that act or exertion of the mind which is necessary to fix in the memory the thoughts and perceptions of which we are conscious. Lord Brougham defines *attention* as "the power by which the mind fixes itself upon a subject."

Circlet—the diminutive from circle, is a little circle, in the same way as *rivulet* is a little river. *Lancet* and *pocket* are diminutives formed by the same analogy. How?

Delusion—from De and Ludo, lusus, *I play*, is a playing with, so as to deceive or be deceived.

Ghost—is connected with our word *gust*, corresponding to the Latin noun Spiritus, and both meaning, literally, *air* or *breath*. The word is now used to signify a vision, a spectre, or apparition. A belief in such appearances is, at the present day, almost wholly confined to men who are young, or ignorant, or the balance of whose mental faculties has in some way been destroyed.

Heathen—supposed to be derived from a Greek word signifying the nations, was originally used as the corresponding word from the Latin, Gentile, was, to signify all nations except the Jews. We use it to signify all nations and peoples not converted to Christianity.

Gift—is no doubt connected with the verb *to give*, and signifies *a thing given* or presented by another.

Habit—is defined as being "a facility of doing a thing acquired by the practice of doing it." Shakspeare refers to this principle when he says:—

> "Refrain to-night;
> And that shall lend a kind of easiness
> To the next abstinence; the next more easy;
> For use can almost change the stamp of nature," &c., &c.

Indolence—from Indoles, *the natural disposition*, means, in use, *slothfulness*, as if this disposition were *native* to all men.

Interpreter—from Interpres, is an "intermediate person through whom one speaks or transacts business with another." Bacon calls man the "interpreter" of nature, because he is able to understand and explain many of her processes.

Mythology—from two Greek words signifying *fable* and *discourse*, is the collective body of a nation's traditions concerning its gods and other fabulous preternatural beings. The classical mythology, *i. e.*, the mythology of Greece and Rome, is usually intended when no distinctive adjective is used along with it. But we speak of the Hindoo mythology, the mythology of the Northern nations, &c.

Reverie—from a French word signifying *to rave*, may be defined as a waking dream. Locke says, "When ideas float in our mind without any reflection or regard of the understanding, it is that which the French call *resvery;* our language has scarce a name for it."

Symbol—from two Greek words signifying *together* and *I throw*, is a term applied to that which comprehends in its figure a representation of something else; hence, an emblem or representation, a letter or character which is significant, &c. The word is used to denote an immense number of things.

Test—from Testa, *an earthen pot*, means anything by which we distinguish the nature of substances from each other; hence, a standard or proof of genuineness, *i. e.*, of a thing being what it is said to be.

MECHANICS.

(p. 257.)

Avoirdupois—from the French, signifies literally, *to have weight*, *i. e.*, to be of the just and true weight according to some acknowledged standard. In *Avoirdupois* weight there are sixteen ounces to the pound, while in Troy weight there are only twelve.

Baalbec—or Balbec, was anciently a large and splendid city known to the Greeks under the name of Heliopolis —*City of the Sun*. It is situated between the ridges of the mountains Libanus and Antilibanus in Syria. The ruins of Baalbec are very grand.

Boatswain — generally pronounced bōsn, from Boat and Swain (Saxon), *a servant*, is an officer on board ships of war whose duty is, amongst other things, to summon the crew to their duty, relieve the watch, seize and punish offenders, &c.

Chronometer—from two Greek words signifying *time* and *a measure*, is a watch of a particular construction. It keeps time with wonderful exactness, and is of great importance to navigators, as it enables them to know the longitude at sea.

Dynamometer—from two Greek words signifying *strength* and a *measure*, is an instrument for measuring the relative strength of men and other animals, and for ascertaining the force required to draw carriages upon roads and vessels upon canals. The word is often contracted into *Dynometer*.

Exactitude—the fact of being exact or accurate. *Exactness* is, perhaps, a more common form of the word. *Exact* is, literally, *worked or wrought out*.

Extraneous — from Extra, *outwards*, foreign, not belonging to the matter. Gold, when found, is mixed with a great deal of *extraneous* matter, *i. e.*, matter that is not gold, and that must be separated from it.

Facilitate—from Facilis, *easy*, is to make more easy, or, in other words, less difficult. Machinery *facilitates* manual labour.

Flexibility—from Flexus, *bent*, is the power of being easily bent without being broken. It is opposed to *stiffness* on the one hand and *brittleness* on the other.

Friction—from Frictus, *rubbed*, is *the act of rubbing against anything*. *Friction* is a retarding force capable of destroying but incapable of generating motion.

Gigantic—from a Greek word signifying *a man of very large stature*, hence, very strong, powerful, &c.

Governor—from Gubernator, *a ruler*, one who rules or governs. The name is transferred to an ingenious contrivance connected with the steam-engine, by which the quantity of steam admitted to the cylinder is exactly proportioned to the resistance of the engine, and the velocity kept constantly the same.

Interval—from Vallum, *a stake*, originally meant the space between stake and stake in the rampart of a Roman camp. It is now more generally applied to spaces of time, thus: in the *interval* between the death of Charles I. and the accession of Charles II. Oliver Cromwell swayed the destinies of England.

Intrinsic—from Intrinsecus, *on the inside*, is what belongs to the inner or essential nature of a thing; hence, real, genuine. The *intrinsic* merit of an action is the thing to be looked to.

Iridescent—from Iris, iridis, *the rainbow*, having colours like the rainbow.

Lathe—is the name of a well-known instrument or engine used in turning wood, ivory, or other materials.

Machine—from the Greek, means anything which serves to increase or regulate the effect of a given force. Machines are usually divided into *simple* and *compound*.

Metronome—from two Greek words signifying *a measure* and *a law*, is an instrument for measuring musical time. The instrument was invented in Austria about 1814, and it determines by its vibrations the movement, that is, the quickness or slowness, of musical compositions.

Refractory — from Refractarius, *obstinate, self-willed, unruly*. Shakspeare speaks of "appetites that are disobedient and *refractory*."

Stonehenge—is one of the most celebrated monuments of British antiquity; most probably constructed as a Druidical temple. It is on Salisbury Plain.

Umbrella—a diminutive from Umbra, *a shadow*, is a well-known instrument to keep off rain from us while we are walking. It is described in early dictionaries as "a portable penthouse, to carry in a person's hand to screen him from violent rain or heat." Umbrellas were introduced into England only about 1786. They are now in universal use.

Varnish—(French, Vernis) a fluid which when spread thin upon a solid surface becomes dry and forms a coating impervious to air and moisture. There are several kinds of varnish.

Veneer—is a term used to signify a thin piece of material of a more valuable kind, laid on another of a more common sort, by which the whole substance appears to be of the more valuable sort. The word is generally used with reference to furniture.

PAPER AND PAPER-MAKING.

(p. 287.)

Appreciable—from Ad, Prex, Precis, *a price*, and the termination *able*, means "able to be weighed, measured, or otherwise valued." *Inappreciable*, what cannot be valued, either because it is of so little worth, or so great worth, that we have no means of measuring the value.

Chloride—is a combination of chlorine. Common salt is a *chloride of sodium*; that is, a binary compound of chlorine and sodium. *Chlorine* is a gas, and it gets its name from a Greek word, signifying *green*.

Linen—from Linum, *flax*, is cloth made of flax. Old linen rags are the finest material for making paper. It was first made of rags in 1319.

Manuscript—from Manu, *the hand*, and Scriptus, *written*, is a book written with the hand or pen. Before the invention of printing all books were in manuscript. The contraction for manuscript is MS.; for manuscripts is MSS.

Papier-maché—is the name given to articles manufactured of the pulp of paper, or of old paper ground up into a pulp, bleached if necessary, and moulded into various forms. Tea-trays, waiters, snuff-boxes, &c., are often made of papier-maché.

Papyrus—a plant that grows abundantly in the valley of the Nile; whose soft cellular flower-stem afforded the most ancient material from which paper was made. The manufacture of paper from the papyrus continued in general use down to the end of the seventh century, when it was superseded by the use of parchment.

Prohibit—from Pro and Habeo, *I hold*, is to interdict by authority. God *prohibited* Adam from eating of a certain tree.

Receptacle—from Re and Capio, *I take*, is a place or vessel into which something is received, or in which it is contained.

Size—is a sort of varnish, paint, or glue, used by painters, and in many other trades. It is made from the shreds and parings of leather, parchment, or vellum, boiled in water, and strained.

Texture—from Textus, *woven*, is the disposition of the several parts of any body in connection with each other, or the manner in which the constituent parts are united. We speak of the *texture* of paper being thick or thin, coarse or fine.

NATURAL PHILOSOPHY.

(p. 296.)

Acceleration—from Ad and Celer, *quick*, means the act of increasing velocity or progress. *Accelerated* motion means in mechanics, that which is being continually quickened or made to move faster and faster. A falling body moves towards the earth with an *acceleration* of velocity.

Arragonite—from Arragon, a province in Spain, is a peculiar variety of the carbonate of lime. It is harder than the common variety, and is prismatic instead of rhomboidal.

Astley's Theatre—is a theatre in London celebrated for the feats of horsemanship that are performed there.

Atom—from two Greek words signifying *privation* and *what can be cut*, is, literally, what cannot be cut, or a part so small that it cannot be divided.

Bullet—from Bulla, *a lump of lead*, with the diminutive termination *et*, means a little ball of lead or (by transference) iron. These balls are used as shot to load guns, &c.

Collision—from Con and Lædo, *I hurt by striking*, means in mechanics, "the action of one body impinging against or striking another with a certain degree of force."

Cricket—is a game most usual in Kent, with a cricket-ball, bowled and struck with two cricket-bats between two wickets. It comes from a Saxon word signifying a bat or staff. See BRAND'S *Antiquities*.

Cylinder—from a Greek word signifying *to roll*, is just another word for what we call a roller.

Elasticity—from a Greek word signifying *a spring*, is the property which some bodies have of recovering their form and dimension after the force that changed their shape and appearance is withdrawn. Bodies that have this power are said to be *elastic*. Those that have it not are said to be non-elastic.

Impediment—from Pes, pedis, *the foot*, is, literally, anything that gets between our feet so as to prevent us from walking properly. Hence, anything that obstructs or prevents us from doing what we wish to do.

Impenetrability—is one of the essential properties of matter. It is the word used to indicate the fact that no two bodies can occupy the same portion of space at the same instant of time.

Inertia—is a Latin word signifying, properly, *sluggishness*, but in *physics* it means that property of matter by which it is equally indifferent to motion or rest.

Lapidary—from Lapis, lapidis, *a stone*, is one who cuts, polishes, or engraves precious stones.

Melodious—from Greek words signifying a *song* and an *ode*, means what is agreeable to the ear by a sweet succession of sounds.

Molecule—a diminution from Moles, *a lump*, means a corpuscle or atom, single or compound. Molecules are the elementary particles into which all bodies are supposed to be resolvable.

Musket—from the French Mousquet, *a gun*, is the fire-arm used by our regiments of the line. The shape, mode of using, &c., have varied, and will vary from time to time.

Neutralize—from Neuter, *neither of two*, is to render neutral. It is used in different senses in chemistry and natural philosophy, but the etymology of the word will be a sufficient guide to its various uses.

Orbit—from Orbis, *a globe* or *wheel*, is the path that a heavenly body takes in going round the centre about which it revolves.

Ponder—from Pondus, ponderis, *a weight*, is to weigh and consider seriously.

Propel—from Pro, *forward*, and Pello, *I drive*, is to drive on or forward. *Propulsion* is the corresponding noun.

Retarded—from Re and Tardus, *slow*, is the opposite of *accelerated*, and means made slower and slower. The laws of *retarded* motion are the same as those of *accelerated*, but they are inverted.

Velocity—from Velox, *swift*, is measured by the space which a moving body passes through in a given time. *Velocities* may be *uniform*, accelerated or retarded.

LIFE OF FERGUSON.

(p. 339.)

Biography—from two Greek words signifying *life* and *writing*, is the history of the life of an individual. The *history* of a nation is little else than the *biography* of great men. When a man writes memoirs of himself, the work is called an *autobiography*.

Catechism—from a Greek word signifying *I instruct*, is a form of instruction by question and answer. The term is generally applied to books of religious instruction, though many attempts have been made to teach other subjects in the same way.

Contrive—from Trouver (Fr.), *to find out*, is to invent a method of doing a thing. *Contrivance* is the corresponding noun, and it means a plan or method of supplying a deficiency, or of increasing a convenience. Everybody knows the various *contrivances* by which Robinson Crusoe provided himself with the first articles of necessity and comfort.

Curtailment—from the French words Court, *short*, and Tailler, *to cut*, means "shortening a thing by cutting off a part." A *curt* answer would literally mean a *short* answer; but in use it means impudent as well as short.

Delusive—from De and Lusus, *a playing* or *cheating*. *Delusory* is another form of the adjective; and *delusion* is the corresponding noun. "God shall send them strong *delusion*, that they *should* believe a lie."

Entertainment—was formerly used in the restricted sense of "treatment as regards food and accommodation;" according to the old inscription over inn-doors, "Entertainment for man and horse." It now means any source of enjoyment; anything to amuse and divert the mind.

Narrative—from Narro, *I tell*, is a history of any transaction. *Narration* is the mode of telling the story; *narrative* is the thing told. The person who tells the story is the *narrator*.

Orrery—a machine for representing the motions, size, relative distances, &c., of the various bodies that compose the solar system. The machine is called after the name of the inventor (or his patron), in the same way as a safety-lamp is often called a *Davy*. The orrery is to be found in most schools; but it is very little better than a toy.

Patron—is a word borrowed from the Roman law. It means now one who assists another in any way, and who acts as "guide, philosopher, and friend." *Patronage* is the corresponding abstract noun.

Physician—from the Greek word signifying *nature*, would properly mean a student of nature, but in use it means a practitioner of the science of medicine.

Portrait—from Pro and Tractus, *drawn*, means a drawing forth of any person or thing; the representation of an individual, or more particularly of his face.

WHAT WE SEE IN THE HEAVENS.

(p. 351.)

Culminate—from Culmen, culminis, *the top*, is to come to the top or highest point of a circle. *Culmination* is the corresponding noun, and it is defined in astronomical works as being "the passage of a celestial body over the meridian at the highest point of its diurnal circle."

Declination—from De and Clino, *I bend*, is defined in astronomy as being "the angular distance of the body north or south from the equator," and is measured on the great circle which passes through the centre of the body and the two poles, and is, consequently, perpendicular to the equator."—BRANDE.

Diagram—from two Greek words signifying *through* and *I write*, means any figure drawn to illustrate a subject more effectually than words can do.

Ecliptic—from a Greek word signifying *I fail*, is the great circle of the heavens which the sun appears to describe in his annual revolution. It was so named because eclipses only happen when the moon is in the same plane, or very near it.

Equinox—from Æquus, *equal*, and Nox, noctis, *night*, is the time when the sun passes through the equator in one of the equinoxial points. When the sun is in the equator the days and nights are of equal length all over the world, whence the derivation of the term.

Galaxy—from a Greek word signifying *milk*, is the *milky way*, a long bright track or belt of light in the sky, formed by innumerable stars of small magnitude individually.

Heaven—the past participle of the Saxon verb to heave, heaven, *i. e.*, *thrown up*. In the Scottish dialect the word *lift* is used in the same sense:—

> "It is the moon; I ken her horn
> That's blinking in the *lift* sae hie."
> BURNS.

Inclement—from In, *not*, and Clemens, *merciful*, not merciful, wild, savage, inhuman.

Meridian—from Meridies, *mid-day*, is the great circle of the sphere passing through the earth's axis and the zenith of the spectator. It is the circle on which the latitudes are reckoned, commencing from the equator, which it intersects at right angles.

Nadir—from an Arabic word signifying *opposite*, is the point of the heavens diametrically opposite to the *Zenith*. The Zenith and Nadir are the two poles of the horizon.

Phasis—in the plural *phases*, from a Greek word signifying *an appearance*, signifies the various appearances of any body, as of the moon, or of one of the planets, at its different ages, also of the sun and moon in eclipse.

Recreation—from Re and Creatus, *created* or *produced*, is the process of bringing to life or liveliness again. After we have devoted ourselves to any pursuit or employment till we are tired we want *recreation*. Amusement, diversion, pastime, are terms of much the same import.

Solstice—is the name given to those two opposite points in the earth's orbit and to the two periods of the year, at which the sun, in reference to his progress north and south, appears to *stand still*. The summer solstice takes place about the 21st of

June, and the winter solstice about the 21st of December. The points of the ecliptic at which the sun arrives at these dates are called the *solstitial points*.

Vernal —from Ver, veris, *the spring*, belonging to the spring. Milton speaks of

> "*Vernal* bloom and summer's rose."

THE FINE ARTS.

(p. 364.)

Abbreviation — from Ad, and Brevis, *short*, means a *shortening of any process or word*. Abbreviations in writing used to be very common, and are sometimes to be met with yet. *Pro tem.* is used instead of pro tempore, *for the time;* F.R.S. for Fellow of the Royal Society; &c. for et cetera, *and other things;* and many others.

Bronze—from the Italian, is a substance used for casting statues, groups, &c., in a mould, similar in principle to that by which plaster casts are produced. *Bronze* is a compound of copper, tin, and other metals.

Byzantine—from Byzantium, the ancient name of Constantinople, means of or belonging to the city of Constantinople. The term *Byzantine* is applied to historians, artists, &c., who flourished in Constantinople from the 6th to the 16th century.

Chiaro-scuro—from Italian words signifying *clear obscure*, is the art of so disposing the light and shade of a picture, that the objects may stand out and be naturally relieved from one another.

Connoisseur—from the French Connoitre, *to know*, means a person well versed and thoroughly skilled in any science. It is a name very lightly assumed, and often thoughtlessly given.

Crepuscule night—from Crepusculum, *the twilight*, means imperfectly clear. *Crepuscular* is the common form of the adjective.

Crucifix—from Crux, crucis, *a cross*, and Figo, *I fix*, means the figure of Christ upon a cross, or the cross with the figure of Christ upon it. *Crucifixion*, a painting representing the scene of our Lord being put to death on the cross.

Dante—the most famous of Italian poets, was born at Florence in 1265. His great poem is the "Divina Commedia," which consists of three parts, Hell, Purgatory, and Heaven. Dante died in 1321.

Epoch—from a Greek word signifying *I stop*, means a fixed point of time from which dates are numbered, or at which a new computation begins. It is consequently the commencement of an era.

Era or *Æra*—denotes the account of time reckoned from some particular date or epoch, chosen for the commencement of the era. The birth of Christ is our era; the Mahometans reckon their time from the flight of Mahomet from Mecca to Medina, A.D. 622.

Façade—from the French, means the *face* or *front* of any building towards a street, court, garden, or other place. The term is mostly used, however, to signify the principal front of the building.

Fine Arts—the, include painting, architecture, sculpture, poetry, music, dancing. They are distinguished from the arts simply so called, because their end is pleasure and refinement, while the arts mainly aim at what is *useful*. The mason builds a house to defend us from the elements; but the architect aims at making the house *beautiful* as well as *useful*.

Florentine — belonging to Florence, a city in Italy, remarkable for its rich collection of works of art. It is renowned equally for its poets and its painters.

Fresco—from the Italian word signifying *fresh*, is a method of painting by incorporating the colours with plaster before it is dry, by which it becomes as permanent as the wall itself. This method of painting is very ancient.

Genre (French)—is a term used in the fine arts to express a class of pictures that cannot be embraced under the general titles of Landscape, Historical, &c.

Genuine—from Genus, a *kind* or *race*, what is of the race or kind that it pretends to be. The opposite of the word in this sense is *spurious*.

Impaste—is a technical term in painting, signifying to lay the colours on thick and bold. *Impastation* in sculpture means the mixture of different matters, bound together by means of cements capable of resisting the action of fire or air.

Interdict—from Inter and Dico, *I speak*, is to forbid with authority. The term originated in the Roman law, and it is still mostly used in ecclesiastical and legal affairs.

Lorenzo the Magnificent, the most famous of the *Medici*, was born in 1448. He was a munificent patron of the fine arts, and he died in 1492 honoured and revered by all Europe.

Legend—from Legendus, *that must be read*, was the name applied to a work containing lives of the saints and martyrs; but it now means a story not well authenticated. Some legends are beautiful and truthful (even if not true); but for the most part they are the offspring of childish credulity on the one hand, and knavish priestcraft on the other.

Mosaic, or, more properly, Musaic—from a Greek word signifying *polished*, *elegant*, means, in painting, a species of representation of objects by means of very minute pieces of stones or pebbles of different colours, carefully inlaid upon a ground generally of metal.

Parochial—from two Greek words signifying *near* and *a house*, means of or belonging to a *parish*, *i.e.*, an ecclesiastical division of a town or a district of country.

Pioneer—derived most probably from the French word signifying a *pickaxe*, is one who clears the road before an army, and hence one who prepares the way for others.

Preliminary—from Pre, *before*, and Limen, liminis, *the threshold*, is what is to be done before the business commences; something to be treated of before a thing can be judged of on its own merits. Certain treatises *prefixed* to the "Encyclopædia Britannica" go by the name of "Preliminary Dissertations."

Sacristy—from Sacer, *holy*, is an apartment attached to a church, in which the consecrated vessels of the church and the garments of the priests, &c., are deposited. *Vestry*, from Vestis, *a garment*, is another name for the same thing.

Tesselated Pavement—from Tessela, *a small square piece of wood, brick, or stone*, means chequered, spotted like a chess-board, &c.

Velvet—from Vellus, *hair* or *nap*, is a rich kind of stuff used for ladies' dresses and a variety of other purposes. Genoa velvet is most esteemed.

ENGLISH LITERATURE.

(p. 392.)

Antique—from Antiquus, *ancient*, as an adjective, means *old*, *of genuine antiquity;* as a noun, it signifies any piece of ancient art, and generally, such as were made by the Greeks and Romans of the classical age.

Blank Verse—is the name by which the structure of the lines of such works as Milton's *Paradise Lost* and Wordsworth's *Excursion* are distinguished. It has, generally, ten syllables to the line, and the lines do not *rhyme*.

Boccaccio—was a celebrated Italian writer. His most noted work is the 'Decameron.' He was a friend of Petrarch, and his father was a Florentine merchant. He was born in 1313, and died 1375.

Comedy—from two Greek words signifying *a village* and *an ode*, was originally applied to the performances of strolling singers. It now means a dramatic composition of a particular sort. Sheridan's *School for Scandal* is one of the best *comedies* in the English language. Comic is the corresponding adjective, and *Comical* in the sense of ludicrously amusing.

Couplet—from the French, means two verses that rhyme to each other. When three lines terminate with the same sound it is called a *triplet*.

Decade—from Decem, *ten*, is a period of ten years, just as *century* is a period of *one hundred* years. Carlyle, speaking of some institution that had incurred his wrath, says, "It may be *decades*, or it may be *centuries*, but the monster has the iron in her heart, and she must die."

Distich—from the Greek, means a couple of verses that make sense of themselves.

Epic Poetry—is the name applied to poems of an elevated character, describing, generally, the exploits of heroes. The three greatest poems that were ever written belong to this class, and are Homer' *Iliad*, Virgil's *Æneid*, and Milton's *Paradise Lost*.

Erudition—from Erudio, *I instruct*, is generally used with reference to very deep learning and research. *Erudite* is the corresponding noun applied to a person.

Heroic Verse—is that appropriated to epic or heroic poetry; in Greek and

Latin the hexameter; in English the iambic of ten syllables, either with or without the additional short syllable.

Inflection—is the grammatical term for any change made in a word or on it; thus, *gave* is an inflection of *give*, and *wiser* is an inflection of *wise*. The English language has very few inflections as compared with the ancient, and several modern tongues.

Invective—from In and Vectus, *carried*, means harsh censure directed against any person. *The Philippics* of Demosthenes are the most famous *invectives* that have come down to us from ancient times.

Inventory—from Invenio, *I find out*, is a list or catalogue of things.

Language—from Lingua, *the tongue*, has been defined as "the expression of our ideas and their various relations by certain articulate sounds, which are used as the signs of those ideas and relations." There are two sorts of language, *spoken* and *written*. It has been estimated that there are upwards of 2000 languages spoken among men.

Literature—from Litera, *a letter*, comprises, in a general sense, the entire results of knowledge preserved in books, but we draw a distinction between literature and positive science.

Lucidity—is the abstract noun from Lucidus, *clear*, probably connected with Lux, lucis, *light*. *Lucidness* is sometimes used in the same sense.

Luminary — from Lumen, luminis, *light*, means any body giving out light, The candle that enables me to write and the sun in the firmament are equally *luminaries*.

Lyric Poetry—is the general name given to *odes*, because they were intended to be accompanied by the *lyre*—the great musical instrument of antiquity. Horace is one of the greatest *lyric* poets that ever lived.

Mediæval—from Medius, *the middle*, and Ævum, *an age*, is of or belonging to the middle ages. The thousand years that intervened between the 5th and 15th centuries usually go by this name.

Norman Conquest—this took place in 1066, when William I., Duke of Normandy, invaded England and subdued it.

Obsolete—from Obsoletus, *that is no longer in its ordinary condition*, hence, old, worn out, &c. *Obsolescent* is what is beginning to grow old, and, as we say, to be out of date. The word "erst," for instance, is now *obsolete*, except in poetry, and other words are *obsolescent*, *i.e.*, going out of use.

Polemical Writings—from a Greek word signifying *war*, mean controversial writings, and are mostly on theological subjects.

Political Economy—may be said to be to a state what private economy is to a single family. The word Political comes from the Greek word signifying *a city* or *state*, and the word Economy from two Greek words signifying *a house* and *a law*. Adam Smith is generally acknowledged to be the father of the modern science of Political Economy.

Racy—what shows (by good qualities) the *race* or root it is of, savouring of the right vintage, and hence, of the right kind or sort.

Regicide—from Rex, regis, *a king*, and Cædo, *I kill*, is one who kills a king, but in use it means one who does so unjustly. Some people speak of Cromwell and his associates as *Regicides*, but this is language dictated by party malice. They may have been right or wrong, but what they did, they did in the light of day and in the face of heaven, and are not to be ranked with assassins.

Revolution — from Re and Volutus, *rolled*, is the overturning of the established state of things. In English history the term is always applied to the year 1688, when William III. came to the throne on the forced abdication of James II. The French Revolution of 1789, and the American Revolution of 1776, are two of the most famous in history.

Rhyme—from a Greek word signifying *measure*, means the correspondence of sounds in the last words or syllables of verses. These two lines are said to rhyme:—

> "Of the three hundred grant but *three*
> To make a new *Thermopylæ*."
>
> BYRON.

Romance—is a term used in literature to signify "a work of fiction in prose or verse, containing the relation of a series of adventures, either marvellous or probable."—BRANDE.

Sonnet—from the Italian, is a short poetical composition, generally of fourteen lines, rhymed according to an intricate, and not always obvious, arrangement. Dante and Petrarch amongst the Italians, and Shakespeare, Milton, and Wordsworth among ourselves, have produced some of the noblest specimens of the sonnet.

Tasso—one of the greatest of Italian poets, was born in 1544. His great work is *Jerusalem Delivered*, which has been finely translated by our Fairfax. He was long confined to a madhouse, and died miserably in 1595.

Tragedy—from two Greek words signifying *a goat* and *a song*, is a species of drama, in which the diction is elevated and the catastrophe miserable. Shakespeare's *tragedy* of "Macbeth" is one of the noblest of human efforts.

Virgil—one of the most distinguished poets of ancient Rome, was born in the year B.C. 70. He died in the 52nd year of his age, leaving to the world the *Æneid* and other poems, that will transmit his name with honour to the most distant age.

Vocabulary—from Vocabulum, *a word*, is a list of words in a language.

Wicklif—the morning star of the Reformation, was born in Yorkshire in 1324. He nobly opposed priestly domination, and performed a service to England, never to be forgotten, by translating the Sacred Scriptures into the vernacular. He died in 1384. Among Wordsworth's *Sonnets* will be found a magnificent one to his memory.

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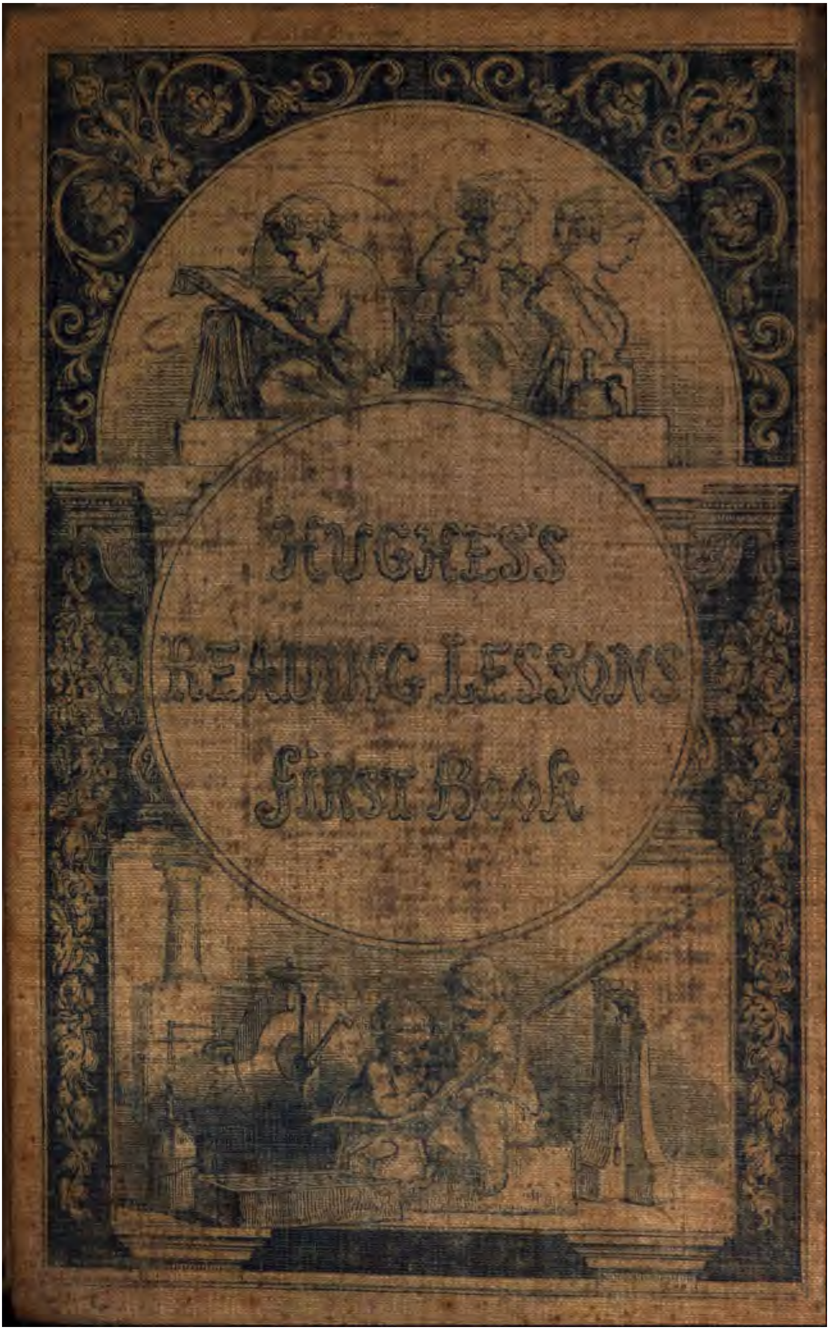

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